State of California
THE RESOURCES AGENCY

Department of Water Resources

Northern Branch

BULLETIN NO. 136

NORTH COASTAL AREA INVESTIGATION

ALTERNATIVE PLANS FOR DEVELOPMENT

Office Report

APRIL 1965

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
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FOREWORD

This report was prepared as a supporting technical document for Bulletin No. 136, "North Coastal Area Investigation". Two other office reports which are associated with Bulletin No. 136 are entitled, "Project Hydrology" and "Designs and Cost Estimates". The separately bound appendixes to the main bulletin are:

Appendix A - Watershed Management in the Eel River Basin

Appendix B - Recreation

Appendix C - Fish and Wildlife

Appendix D - Related Reports (included in the main bulletin)

Appendix E - Engineering Geology

In the main bulletin the emphasis is on concepts, conclusions and recommendations rather than on reporting of data. Many alternative plans of development were analyzed during the investigation. The plans presented in Bulletin No. 136 were selected as the more favorable of the alternatives. This office report was prepared in the interest of preserving basic information and the analyses pertaining to various North Coastal area developments. Part I of this report presents discussions, diagrams, maps and tables relating to the various plans for the North Coastal streams. Part II presents further information on the alternative projects by means of graphical illustrations and detailed explanations.

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State of California
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DEPARTMENT OF WATER RESOURCES

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PART I

ALTERNATIVE PLANS

CHAPTER I. INTRODUCTION

With the publication of Bulletin No. 136, the Department of Water Resources concluded the seven-year reconnaissance phase of the continuing North Coastal Area Investigation. The need for this investigation arose from the conclusions of Bulletin No. 3, "The California Water Plan". That document, which culminated ten years of study by the Division of Water Resources, the predecessor of the Department, concluded that there is, in fact, sufficient water in California to satisfy the State's long-range water requirements if the available resources are wisely controlled, conserved, and distributed.

With the recognition that much of the future water requirements in the State would be met from North Coastal supplies, it was apparent that a planning framework was needed to assure that each new project in this area represented a logical and orderly increment in long-range development. The basic need was to translate the broad planning concepts reported in Bulletin No. 3 into a workable plan of staged project development.

Program Objectives

The objective of the North Coastal Area Investigation is to formulate plans for the optimum development of the water resources of the region, considering all potential purposes, including anticipated local and export water supply needs; enhancement of fish and wildlife resources; development of hydroelectric power; development of water-associated recreation potential; and protection against floods. The specific objectives of the reconnaissance phase of the investigation were:

1. To formulate a comprehensive planning framework through which the water resource potential of the North Coastal area can be integrated with California's expanding economy through orderly, staged development.

2. To identify and outline the essential features of the initial additional conservation facility of the State Water Project in the North Coastal area.

3. To determine for the succeeding incremental sources of major water supply in the North Coastal area possible plans for development, the logical sequence of development, the order of magnitude of associated capital investment, and the scale of project accomplishments.

4. To evaluate the potential for integration of hydroelectric power, flood control, recreation, and fisheries and wildlife enhancement with the works of the major water conservation facilities.

5. To identify problem areas that will require specific study when the water development plans are investigated at a higher level of intensity.

6. To provide recommendations relative to programs and actions which will be necessary to effect efficient, orderly, and optimum development of the region's water resources.

Scope of Investigation

The plan of development as presently conceived would include major projects in the Eel, Trinity, Mad, Van Duzen, Klamath, and Russian River Basins. Minor coastal drainage basins extending north from the Gualala River to Redwood Creek, were given cursory examination as possible locations for fisheries enhancement projects.

In addition to the above streams which all drain westward to the coast, portions of the contiguous drainage basins on the west side of the Sacramento Valley, through which the exported water would be conveyed en route to the Sacramento-San Joaquin Delta, have also been studied. These basins include Putah, Cache, Stony, Thomes, Elder, Cottonwood, and Clear Creeks. The study of these drainage basins was directed primarily to aspects associated with the interbasin transfer of water, such as possible reregulatory storage sites and hydroelectric power features; however, substantial additional benefits, including conservation of tributary runoff, would be derived from works constructed in these basins.

Many alternative plans of development were analyzed during the investigation. The plans presented in Bulletin No. 136 were selected as the most favorable of the alternatives. This office report was prepared in the interest of preserving the analyses and conclusions pertaining to the plans which were given the greatest consideration.

Part I of this report presents discussions, diagrams, maps, and tables relating to the various plans for the North Coastal streams. Part II presents further detailed information, by means of graphical illustrations, on the alternative North Coastal projects.

CHAPTER II. UPPER EEL RIVER BASIN

The Upper Eel River Basin includes three major tributary stream systems: the North Fork Eel, Middle Fork Eel, and upper main Eel. The drainage boundaries, stream pattern, general orientation of this region, and damsite locations are shown on Figure 1. Pertinent topographic and hydrographic data, referenced to damsites, are presented in Table 1.

A number of factors combine to make the Middle Fork Eel the key to any major water conservation project in the Upper Eel River Basin. First, with a long-term average annual runoff of about 1,000,000 acre-feet, sufficient water is available for development of an economic project. In addition, the basin is situated such that diversion to the Sacramento Valley is possible either to the east via Glenn Reservoir or to the south via the upper main Eel, Clear Lake, and Lake Berryessa.

The North Fork Eel offers some possibility for the development of water supplemental to a Middle Fork project. Independent export development on the North Fork is precluded by the relatively small amount of runoff, approximately 400,000 acre-feet annually, and the long tunneling distance from the Sacramento Valley.

Formulation of a project on the upper main Eel is greatly affected by the existing power development of the Pacific Gas and Electric Company. The quantity of water remaining for possible new development is not sufficient to justify export to the Sacramento-San Joaquin Delta as an independent project. However, it does appear feasible to construct a major reservoir project on this stream for the following general purposes: (1) to develop new water supplies to meet requirements in local and adjacent basins; and (2) to serve as an integral link in the conveyance system for exporting Middle Fork Eel flows to the Delta.

In the following sections the plans for development which were studied for the three major tributary streams in the upper Eel River Basin are discussed.

Middle Fork Eel River

The Middle Fork Eel River is the largest stream system of the three drainage areas which comprise the Upper Eel River Basin. It rises on the

LOCATION OF DAMSITES
UPPER EEL RIVER BASIN

SCALE OF MILES

TABLE 1

UPPER EEL RIVER BASIN

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Mina	N.F. Eel R.	Sec. 5, T24N, R13W, MDB&M	246	368	1,040	For diversion to M.F. Eel River
Upper Mina	N.F. Eel R.	Sec. 28, T5S, R8E, HB&M	224	334	1,260	Alternative to Mina
Red Mtn.	N.F. Eel R.	Sec. 31, T4S, R8E, HB&M	112	167	1,475	Alternative to Caution
Caution	N.F. Eel R.	Sec. 31, T4S, R8E, HB&M	110	165	1,530	Local development - Bulletin No. 3
Shannon	N.F. Eel R.	Sec. 13, T4S, R7E, HB&M	89	133	1,700	Power dam - import from Mad-Van Duzen
Soldier Cr.	Soldier Cr.	Sec. 10, T3S, R7E, HB&M	5	8	2,380	Power dam - import from Mad-Van Duzen
Dos Rios	M.F. Eel R.	Sec. 4, T21N, R13W, MDB&M	745	1,022	925	Possible key feature of U. Eel R. Dev.
Round Mtn.	M.F. Eel R.	Sec. 4, T21N, R12W, MDB&M	713	999	1,050	Alternative to Jarbow
Jarbow	M.F. Eel R.	Sec. 4, T21N, R12W, MDB&M	712	998	1,060	Alternative to Dos Rios
Lower Etsel	M.F. Eel R.	Sec. 24, T22N, R12W, MDB&M	441	759	1,250	Bulletin No. 3 site
Etsel	M.F. Eel R.	Sec. 12, T22N, R12W, MDB&M	432	744	1,282	Alternative to Spencer
Spencer	M.F. Eel R.	Sec. 1, T22N, R12W, MDB&M	426	735	1,340	Possible feature of U. Eel R. Dev.
Elk Cr.	Elk Cr.	Sec. 32, T21N, R11W, MDB&M	83	72	1,275	Possible pump-lift (Deep Hole Dam)
Mill Cr.	Mill Cr.	Sec. 23, T22N, R12W, MDB&M	97	86	1,280	Dike to protect R. Valley in High Dos Rios Pla
Franciscan	Short Cr.	Sec. 28, T23N, R 12W, MDB&M	16	14	1,395	Dike at head of Round Valley
Willis Ridge	Eel R.	Sec. 32, T21N, R 13W, MDB&M	527	713	1,000	Bulletin No. 3 site
English Ridge	Eel R.	Sec. 6, T19N, R 12W, MDB&M	488	654	1,180	Possible feature of U. Eel R. Dev.
Garcey	Eel R.	Sec. 22, T19N, R12W, MDB&M	461	613	1,323	Alternative to English Ridge
Marshall	Eel R.	Sec. 1, T18N, R12W, MDB&M	425	561	1,386	Alternative to English Ridge
Pressley Ranch	Eel R.	Sec. 34, T18N, R11W, MDB&M	340	441	1,505	Possible feature of U. Eel R. Dev.
Benmore	Eel R.	Sec. 13, T18N, R11W, MDB&M	312	405	1,608	Alternative to Pressley

western slope of the Coast Range Divide at an elevation of about 6,000 feet. At its confluence with the main Eel at Dos Rios, the Middle Fork has drained 753 square miles and has fallen to a streambed elevation of 900 feet. The principal geographic feature in the basin is Round Valley. This valley contains 18,000 acres, which is about 25 percent of all the agricultural land in Mendocino County. The town of Covelo, in the center of the valley, is the only settlement of any size in the Middle Fork Basin. About half of the valley's 1,500 residents live in Covelo.

Purpose of Middle Fork Development

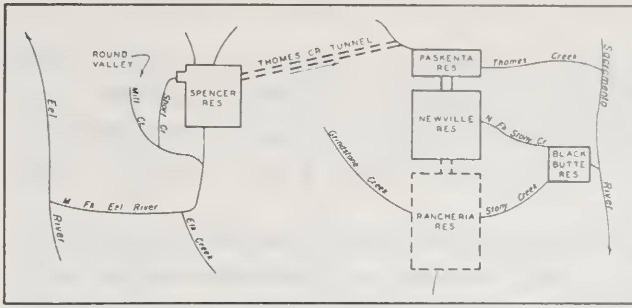
The Middle Fork Eel River will be the source of water for the initial state export project in the North Coastal area. The primary purpose of the development will be to augment water supplies in the Sacramento-San Joaquin Delta so as to prevent a reduction in the minimum yield of the State Water Project. The development will also provide local water service, recreation, power generation, and flood control. The physical works described in this section are the conservation features for developing the water and the conveyance facilities for diverting the water from the basin.

Alternative Plans for Development

This section presents a discussion of the alternative physical plans by which water could be developed on the Middle Fork Eel and diverted from the basin. Emphasis is directed toward comparative scales which the plans represent and recognition of the functional features of the plans, rather than toward engineering details. Discussion of the specific project features which comprise the various plans is given in the next section.

For purpose of presentation, the Middle Fork plans are grouped in two classes in this section: (1) plans involving export via Glenn Reservoir, and (2) plans involving export via the upper main Eel. Four basic alternatives in each class are presented.

Plans Involving Diversion to the Glenn Complex. Each of the four basic plans discussed in this section includes one or two conservation reservoirs on the Middle Fork Eel River and a tunnel of about 20 miles in length to either Thomes or Grindstone Creek, and the Glenn Complex. A schematic drawing showing the essential features of each plan is presented in Figure 2. Pertinent information about the plan is summarized on each drawing.

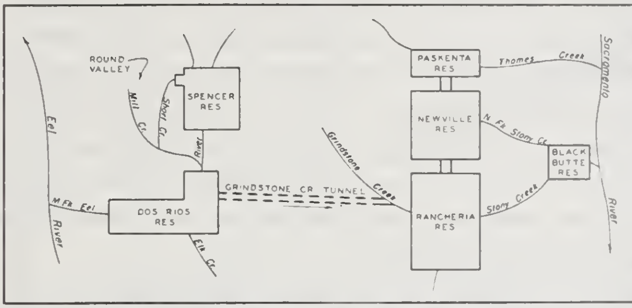


PLAN: [illegible]ate[illegible] [illegible]pe[illegible] [illegible]pencer [illegible] would be [illegible]erte[illegible] [illegible] Tunnel to the Pa[illegible]ke[illegible]ta-Newvil[illegible]e compartment[illegible] of the Glenn Reservoir comp[illegible]x.

DATA: Average annual [illegible]: [illegible] AF
[illegible]pencer [illegible] gross storage: [illegible] AF
[illegible]pencer [illegible]eser[illegible] [illegible] ft.
Approx[illegible]mate [illegible]eight of [illegible]pencer Dam: [illegible] ft.

DISCUSSION: This plan ha[illegible] been shown previously by the Department [illegible] Bulletin No. [illegible] [illegible]plan would develop [illegible] acre-feet [illegible] new annual yield, referenced to the Sacramento-[illegible]an Joa[illegible] Delta. On the basis of minimum [illegible]al expenditure [illegible] the most economical alternative [illegible] routing via Glenn. The plan does not, however, develop the full potential of the Middle Fork, and [illegible] represent the most favorable long-range development.

REFERENCE: Figure [illegible], curve A; Summary Plate [illegible]

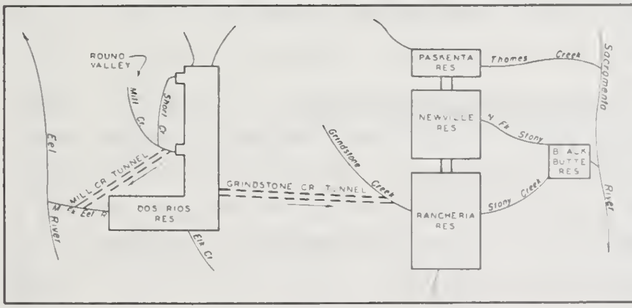


PLAN: Wat[illegible] developed in Spence[illegible] an[illegible] Do[illegible] Rese[illegible]voirs would be diverted through Gri[illegible]e Creek Tunnel.

DATA: Average annual diversion: 66[illegible],000 AF
Spencer Reservoir gross storage: 47[illegible],00[illegible] AF
Spencer Reservoir N.[illegible] Elev.: 164[illegible] ft.
Dos Rios Reservoir gross storage: [illegible]6[illegible],000 AF
Dos [illegible]io[illegible] Reservoir N.W.[illegible] Ele[illegible]: [illegible]1[illegible]25 ft.

DISCUSSION: Although not provi[illegible]ing f[illegible] full develop[illegible]ment of the Middle Fork, this plan would develop considerably more water than a plan with Spencer Reservoir alone. A possible variation of this plan, which has not as yet been analyzed, would be to make the diversion from Spencer Reservoir and pump water from Dos Rios Reservoir into Spencer Reservoir. In any plan with a low Dos Rios Reservoir, Round Valley would be protected by limiting the normal water surface elevation to approximately 1[illegible]25 feet.

REFERENCE: Figure 3, curve B; Summary Plate [illegible]

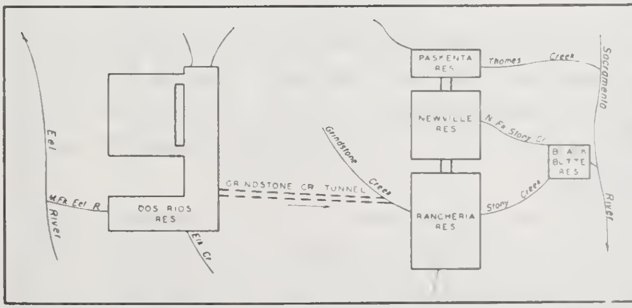


PLAN: [illegible]ater developed in a large Do[illegible] [illegible] Reservoir would be diverted through Gri[illegible]ne Creek Tunnel. Round Valley would be protected by Mi[illegible] Creek and [illegible]an Dams and drained by Mill Creek Tunnel.

DATA: A[illegible]rage annual [illegible]ersion: [illegible] AF
Do[illegible]os Reservoir gross storage: 1,[illegible]00,000 AF
Dos Rios Reservoir N.[illegible] Elev.: 14[illegible] ft.
Approximate height of [illegible] Dam: [illegible] ft.
Approximate [illegible] Mill Creek Dam: [illegible] ft.
Approximate height of Franciscan Dam: 100 ft.

DISCUSSION: Of the [illegible]ans which would n[illegible] [illegible] Valley, this plan would develop the most water. However, the additional increment of yield which this plan would develop, over a plan with Spencer Reservoi[illegible] and a low Do[illegible] [illegible]os Reservoir, would be costly and would probably not be economically justified.

REFERENCE: Figure [illegible], curve C



PLAN: [illegible]ater [illegible] a larg[illegible] [illegible] which [illegible] [illegible] Valley would be diverted [illegible] Grin[illegible] Creek Tunnel.

DATA: Average annual diversion: [illegible] AF
Do[illegible] Reservoir g[illegible] storage: [illegible] AF
Do[illegible] Reserv[illegible]r N.[illegible] Elev.: [illegible] ft.
Approximate height of [illegible] Dam: [illegible] ft.

DISCUSSION: [illegible] plan [illegible] the Middle [illegible] The plan would [illegible] the large storage potential of [illegible] Valley. From an engineering standpoint this plan [illegible]

REFERENCE: Figure [illegible]

ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER

ROUTING VIA GLENN RESERVOIR

NOT TO SCALE

A comparison of the four plans is presented on Figure 3, which shows relationships between cost and yield for each plan. The curves also indicate the range of yields associated with each scale of development. The designation of plans as A, B, C, and D refers only to Figures 2 and 3 and has no other significance.

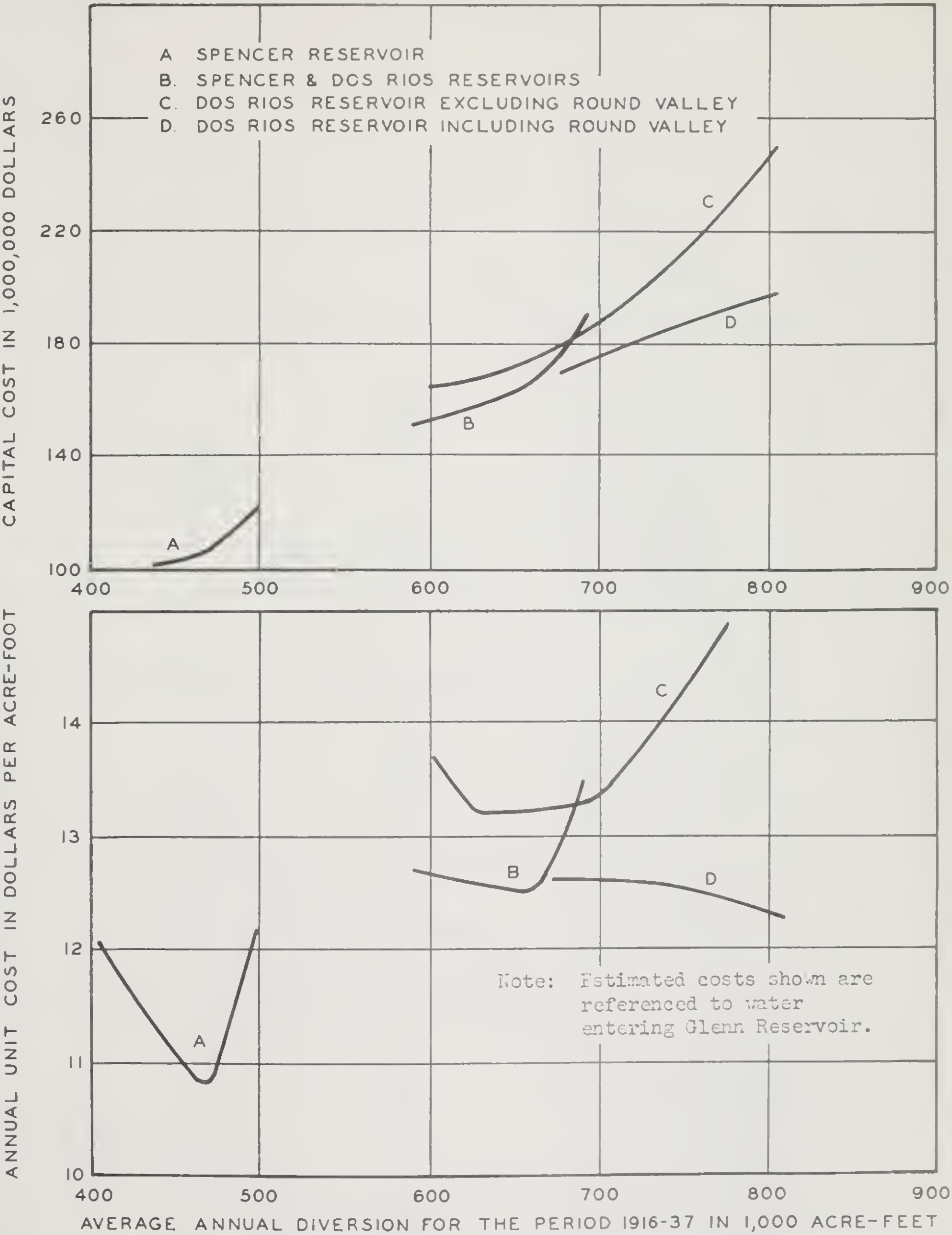
Within each of the plans shown there are internal alternatives, which, although judged to be less favorable, are nonetheless engineeringly feasible. The accomplishments and costs of these alternatives would differ from the plans shown, but would fall within the basic scales of development. Plan A, showing Spencer Dam and Reservoir could instead include Etsel Dam and Reservoir. Plan B, showing Spencer Reservoir with a low Dos Rios Reservoir could include instead either of the following: Spencer and Jarbow Reservoirs, Etsel and Jarbow Reservoirs, or Etsel and Dos Rios Reservoirs. Plans C and D, which show a large Dos Rios Reservoir, including and excluding Round Valley could include instead a large Jarbow Reservoir.

Summary Plate 3 was prepared to show the accomplishments of the Glenn Complex with various imports from the Middle Fork Eel River. This plate is discussed further under the Glenn Reservoir Complex in Chapter IV.

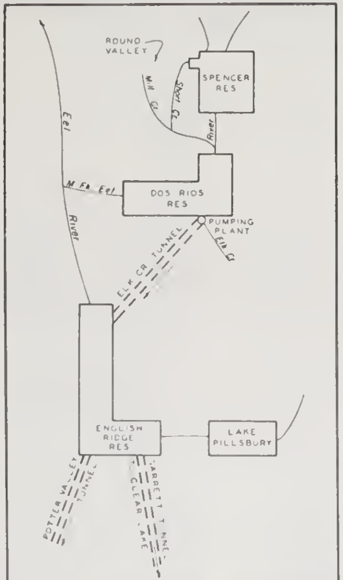
Plans Involving Export via Upper Main Eel. The four basic plans for developing water on the Middle Fork Eel and diverting it via the upper main Eel are shown schematically on Figure 4. In all of the plans English Ridge Reservoir is shown as the receiving reservoir on the upper main Eel River. Generally speaking, any of the alternative plans of development for the upper main Eel River would be compatible with any of the Middle Fork plans presented here.

A comparison of the four plans is presented on Figure 5, which shows the relationship between cost and yield for each. The curves also indicate the range of yield associated with each plan. The designation of the plans in this section as W, X, Y, and Z refers only to Figures 4 and 5 and has no other significance.

Within each of the basic plans shown, there are internal alternatives, which, although judged to be less favorable, are nonetheless engineeringly feasible. The accomplishments and costs of these alternatives would differ from the plans shown, but would fall within the basic scales of development. Plan W, which shows a low Dos Rios Reservoir with an upstream Spencer Reservoir, could instead be comprised of: Dos Rios and Etsel Reservoirs;



TOTAL CAPITAL AND ANNUAL UNIT COSTS OF AVERAGE ANNUAL DIVERSION FOR THE PERIOD 1916-37 DERIVED FROM MIDDLE FORK EEL RIVER AND DELIVERED TO GLENN RESERVOIR

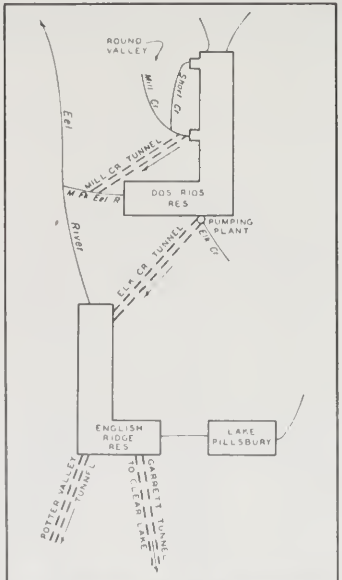


PLAN: Water deve[illegible]ped [illegible] voir[illegible] woul[illegible] pumped through [illegible] Creek [illegible] English Ridge Re[illegible]ir.

DATA: Firm annual exportable yield: [illegible],000 AF
Spencer [illegible]eservoir g[illegible] capacity [illegible] AF
Spencer [illegible]eservoi[illegible] N.W.[illegible] Elev.: [illegible] ft.
Approximate [illegible] of [illegible] Dam: [illegible] ft.
[illegible] AF
Do[illegible] N.W.[illegible] Elev.: [illegible] ft.
Approximate [illegible] Dam [illegible] ft.

[illegible]: [illegible] plan, wh[illegible] No. 13[illegible], represent[illegible] the smallest pra[illegible]al [illegible]ale of development f[illegible]r exp[illegible]ing [illegible]urpl[illegible] water f[illegible] the Middle F[illegible]rk via the upper Eel River. The features of this plan are those whi[illegible]h are menti[illegible]ned specifically i[illegible] the pr[illegible]ject order whic[illegible] aut[illegible]izes the Upper Eel River Development.

[illegible]: [illegible] W, [illegible] Plate [illegible]

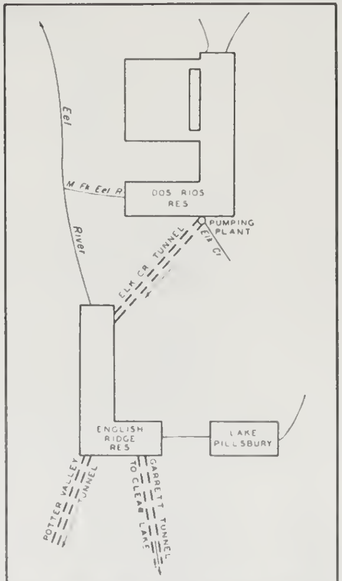


[illegible] a la[illegible]ge [illegible] Creek Tun[illegible] English [illegible]dge Reser[illegible]oir. [illegible]ound Valley would be protected by Mill [illegible]reek and Franciscan Dams and would be drained by Mill Creek Tunnel.

[illegible]: Firm an[illegible]ual exportable yield: 600,000 AF
[illegible] capa[illegible]ity: [illegible],000,[illegible]
Do[illegible] N.W.[illegible] Elev.: [illegible] ft.
App[illegible]ximate [illegible] Dam: [illegible]

[illegible]: Thi[illegible] plan [illegible] possible without [illegible] Valle[illegible] releases to [illegible]ound Valley for local requiremen[illegible] woul[illegible] be made from Franc[illegible]scan Dam.

[illegible]: [illegible] X; [illegible]

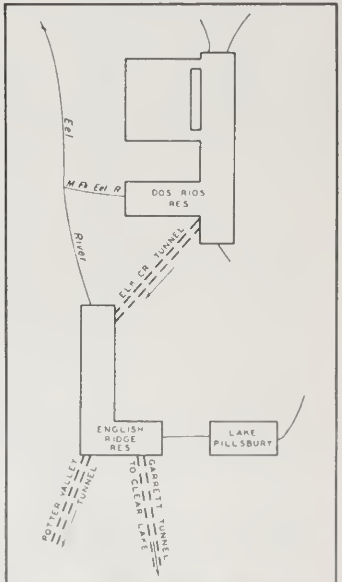


[illegible]: [illegible] in a large [illegible] storage potential [illegible] Valley would be pumped through Elk [illegible]eek Tu[illegible]ne[illegible] to English Ridge Reservoir.

DATA: Firm annual exportable yield: 800,000 AF
Do[illegible] Rios Reservoir gross capacity: 4,100,00[illegible] AF
Do[illegible] Rio[illegible] Reservoir N.W.S. Elev.: [illegible] ft.
Approximate height of D[illegible]s Rios Dam: [illegible]

[illegible]: Both thi[illegible] plan and the grav[illegible] shown [illegible]n the right would enable f[illegible] development of the Middle Fork. A compa[illegible] the two plans is presented on Plate [illegible].

[illegible]: [illegible] Y; [illegible]



PLA[illegible]: [illegible] Valley would be diverted b[illegible] gravity th[illegible] Creek Tunnel to English [illegible]idge [illegible]eserv[illegible].

DATA: Firm annual exportable yield: [illegible] AF
Do[illegible] Rio[illegible] [illegible]eservoir gross capa[illegible]it[illegible]: [illegible]
Do[illegible] Rio[illegible] [illegible]ese[illegible]voir [illegible]nactive capacity: 4,[illegible]
[illegible] N.W.[illegible] Elev.: 1[illegible] f[illegible]
Approximate height of Do[illegible] Dam: [illegible]

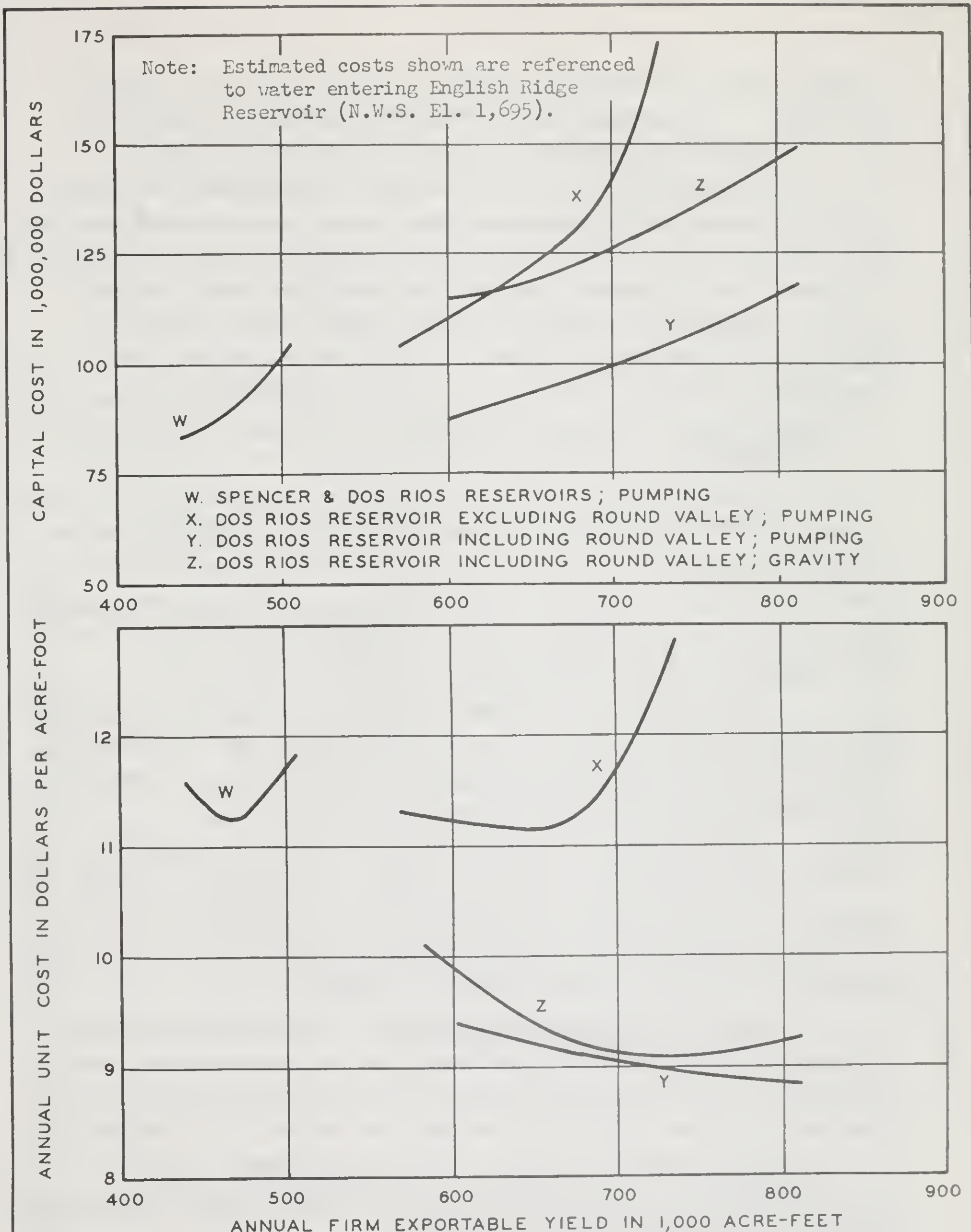
[illegible]N: The [illegible] ca[illegible]e[illegible] that the [illegible] a[illegible]soc[illegible]a[illegible]ed w[illegible] [illegible]ina[illegible]ti[illegible]e storage in this plan make[illegible] it a le[illegible] fa[illegible]orable alternative than the pump[illegible]ng plan.

[illegible]: [illegible]gure [illegible]

ALTERNATIVE PLANS FOR DEVELOPMENT
OF MIDDLE FORK EEL RIVER

ROUTING VIA UPPER EEL RIVER

NOT TO SCALE



TOTAL CAPITAL AND ANNUAL UNIT COSTS OF FIRM EXPORTABLE YIELD DERIVED FROM MIDDLE FORK EEL RIVER AND DELIVERED TO ENGLISH RIDGE RESERVOIR

Jarbow and Etsel Reservoirs; or, Jarbow, Etsel, and Elk Creek (Deep Hole) Reservoirs. Plan X, which shows a large Dos Rios Reservoir with Round Valley protected, could instead include a large Jarbow Reservoir.

Plates 15, 16, and 17 were prepared to summarize various aspects of alternative plans for development which involve export via the upper main Eel. The plan shown on these plates do not correspond directly with the plans in Figures 4 and 5; however, they are functionally the same. The plates contain a wealth of information about Middle Fork alternatives and certain key conclusions regarding elimination of alternatives are illustrated graphically. A brief summary of the essential points of each of these plates is presented below. An expanded discussion of each plate is given in Part II of this report.

Plate 15 shows cost and yield data for a plan comprised of Spencer, Jarbow, and Elk Creek Reservoirs. This plan can be considered an internal alternative to Plan W. The main purpose of Elk Creek Reservoir would be to provide additional conservation storage to the plan. However, the high cost of reservoir storage at the Elk Creek site, as illustrated in Chart 15-E, has eliminated it from further study at this time.

Plate 16 shows a comparison of Etsel and Spencer Reservoirs and Dos Rios and Jarbow Reservoir. The relatively higher cost of storage in Etsel and Jarbow Reservoirs, as indicated in Chart 16-G, is the basis for the judgment that they are less favorable alternatives.

Plate 17 shows a comparison of pumped and gravity diversion from a large Dos Rios Reservoir which would inundate Round Valley. Although the unit cost of yield from either alternative would be comparable, the higher capital cost associated with the large inactive storage in the gravity plan makes this appear to be a less favorable alternative.

Factors Affecting Route Selection. The two previous sections described plans for developing the Middle Fork Eel River under the two alternative diversion routes: either to the east via Glenn Reservoir or to the south via Clear Lake. One of the major objectives of the feasibility-level planning program for the Upper Eel River Development is selection of the conveyance route. The factors which are presently recognized as having a bearing on the selection are as follows:

1. Total capital cost
2. Affect on Delta Water Rate of State Water Project

3. Financing --relative state-federal participation
4. Water supply requirement of State Water Project in Delta
5. Water supply requirement of Bureau of Reclamation in Delta
6. Operational criteria related to firming Delta surpluses
7. Opportunity of staging construction
8. Possible effects on seepage in Sacramento River
9. Possible water rights problems in Sacramento River
10. Nonreimbursable benefits: flood control, recreation, fish enhancement
11. Clear Lake water quality problems
12. Magnitude and timing of associated local water requirements
13. Feasibility of Eel-Glenn Tunnels
14. Opportunity of sharing Glenn Reservoir with future Trinity River developments

Physical Works of Alternative Plans

Spencer Dam and Reservoir. Spencer Dam and Reservoir is the farthest upstream site considered for major development on the Middle Fork Eel. It could be either the sole conservation feature for a diversion project to Glenn Reservoir or the upstream reservoir for diversion to Glenn or English Ridge Reservoirs. Spencer Reservoir requires construction of Franciscan Dam on Short Creek at the entrance to Round Valley. This dam prevents the inundation of Round Valley and allows the addition to the reservoir of Williams Valley, which is separated from the Middle Fork by a low saddle.

It is presently considered that Spencer Dam would have a rockfill section. The damsite has been drilled and has had extensive geologic exploration. However, additional investigation is necessary to fully determine the competency of the left abutment, and to determine the availability of suitable rockfill materials for construction. The highest dam considered for this site would be 385 feet and would impound a reservoir of 850,000 acre-feet.

Etsel Dam and Reservoir. Etsel Dam is a basic alternative to Spencer Dam. Etsel Reservoir also requires construction of Franciscan Dam on Short Creek. Etsel Reservoir would have considerably more storage than Spencer Reservoir because of the addition of Etsel Flats to the reservoir area. However, the relatively higher cost of storage appears to make it a less favorable alternative.

There are actually two sites which have been called Etsel during this investigation. The lower one, which has been drilled, is located on the Middle Fork Eel River about 1.4 miles upstream from Mill Creek. This site has been rejected on the basis of unfavorable foundation conditions. The upper site, located about 2.6 miles upstream from Mill Creek, which is being considered by the Department, is also being studied by the U. S. Bureau of Reclamation. It has not been drilled, but is considered geologically adequate for the heights of dam considered. The Bureau of Reclamation's reconnaissance studies included a dam at this site 428 feet high, impounding a reservoir of 1,425,000 acre-feet.

Franciscan Dam. Franciscan Dam would be a dike on Short Creek at the entrance to Round Valley. It would be required for Spencer or Etsel Reservoirs or for a high Dos Rios or Jarbow Reservoir to prevent inundation of Round Valley. The site has been drilled for the higher dams, but there are some questions about its competency. The highest dam considered for the site would be about 310 feet high.

Dos Rios Dam and Reservoir. As shown on Figures 2 and 4, Dos Rios Dam and Reservoir could be a key conservation feature of several alternative plans for development of the Middle Fork Eel River. The damsite is considered to be one of the best in the North Coastal area; and based on surface reconnaissance study, geologists consider that it could accommodate a very high dam. Present reconnaissance dam designs call for construction of a rockfill embankment at the Dos Rios site.

Jarbow Dam and Reservoir. Jarbow Dam is a basic alternative to Dos Rios Dam. Although it is 144 feet higher in streambed, the canyon is wider than Dos Rios, hence the cost of storage is higher in the range of dam heights considered. In the first years of this investigation considerable study was made of plans including Jarbow Dam, before it became evident that Dos Rios damsite is more favorable. The Bureau of Reclamation includes a Jarbow Dam and Reservoir in their reconnaissance plan for development of the Middle Fork.

Elk Creek Dam and Reservoir. This dam and reservoir, also known as Deep Hole, is shown in the Bureau of Reclamation's reconnaissance plan for development of the Middle Fork. Its purposes are to provide conservation storage for development of Elk Creek flows and to serve as a stage in the lift from Jarbow to English Ridge Reservoir. The Department's studies indicate that the high cost of storage in the reservoir makes it an unfavorable alternative. The flows from Elk Creek can be conserved in Dos Rios Reservoir and pumped at a lower cost to English Ridge Reservoir than conserving them and pumping them from Elk Creek Reservoir. See plate 16.

Mill Creek Dam. This dam would act as a dike to protect Round Valley from flooding in any of the plans involving a high Dos Rios (or Jarbow) Reservoir. The flow of Mill Creek, which normally drains Round Valley, would be diverted through Mill Creek Tunnel, which would extend from Round Valley to the Middle Fork Eel River. Mill Creek Dam would be above Dos Rios or Jarbow Dams. It would be of earthfill construction, and would be approximately 350 feet high.

Tunnels. The tunnels described in this section are those associated with the alternative plans for development of the Middle Fork Eel River.

In consideration of the great lengths of the various tunnel alignments, the minimum tunnel diameter considered was 10 feet. Limited subsurface exploration has been made for the alignments to Glenn Reservoir. Tunneling conditions for the remaining alignments were based on surface exploration only. Detailed information about geology of the tunnels is presented in the Geology Appendix.

The problem of obtaining reasonable reconnaissance cost estimates for the tunnels was made quite difficult by the absence of detailed information on tunneling conditions and by the unprecedented length of the alignments. The tunnel cost estimates below are based on a method developed specifically for these studies by the Northern Branch Design Unit. The method is outlined in an office report on the subject. A discussion of criteria and assumed conditions for each tunnel is given in the Design and Cost Estimating office report.

Spencer Powerplant. In plans which include Spencer Reservoir and a downstream reservoir, either Dos Rios or Jarbow, it would be possible to generate hydroelectric power at Spencer Dam. During the investigation several studies were made to determine the relationships between costs of water yield, quantities of water yield, and possible capacity factors of such a powerplant. Generally speaking, it was found that power generation at Spencer Dam would be economically marginal. The decision to include or exclude a powerplant

TABLE 2

TUNNEL DATA
MIDDLE FORK EEL RIVER - ALTERNATIVE PLANS

Tunnel	Length (Miles)	Yield (or) Capacity (AF Per Yr)	Dia. (Ft)	Estimated Capital Cost
Spencer-Thomes Creek Tunnel	20.1	470,000	10	$75,000,000
Dos Rios-Grindstone Creek Tunnel	23.2	Up to 800,000	12	116,000,000
Mill Creek Tunnel (Below Jarbow Dam)	2.9	---	12	11,100,000
Mill Creek Tunnel (Below Dos Rios Dam)	5.1	---	12	23,300,000
Elk Creek Tunnel	7.3	500,000	11	22,000,000
		600,000	12	23,500,000
		700,000	13	25,500,000

is quite sensitive to the value of power. Since the assumed value of power used in these studies is subject to major revision, the conclusions should be considered indicative rather than final. It is anticipated that with a reduction in the unit value of power revenue, a powerplant at Spencer would not be economical.

One of the more favorable plans studied included a powerplant which would operate on a 50 percent capacity factor in coordination with the Elk Creek Pumping Plant. This would effect a savings in not having to duplicate transmission lines to the load center. It was also concluded that the most economical reservoir operating range would be where minimum net head on the powerplant was one-half maximum head.

Charts I and J of Plate 16 summarize some of the studies relating to Spencer Powerplant. Chart J illustrates that revenues from power exceed the costs only for yields near the maximum. The chart also indicates that at a capacity factor of 50 percent, the installed capacity would be between 25 and 30 megawatts.

Etsel Powerplant. For all practical purposes, and in the context of a reconnaissance-level study, the conclusions pertaining to a Spencer Powerplant also apply for an Etsel Powerplant.

Elk Creek Pumping Plant. The purpose of an Elk Creek Pumping Plant would be to lift water developed on the Middle Fork to English Ridge Reservoir on the upper main Eel. The conveyance facilities would be comprised of the pumping plant, discharge penstocks, and an Elk Creek Tunnel. Depending on the water surface fluctuation associated with operation of Jarbow or Dos Rios Reservoir, the pumping plant might have to be an underground installation.

It is possible to size the Elk Creek conveyance facilities, defined above, for either a "continuous" or "off-peak" pumping schedule. The latter schedule would require larger sizing of the conveyance facilities but would take advantage of much lower power and energy costs associated with off-peak power. An analysis comparing these two alternatives was made. The results, illustrated on Chart 15-H, indicate it is probably more favorable to size for "continuous" operation.

It is possible that the pumping plant could operate in conjunction with a powerplant at Spencer or Etsel Dam. At a 50 percent capacity factor, the powerplant would have slightly more capacity than required at Elk Creek

Pumping Plant. Thus, power from Spencer or Etsel might be used during peak hours at Elk Creek, and low cost power and energy purchased commercially for offpeak operation.

Provision for In-basin Releases

The alternative plans for the Middle Fork Eel River described earlier in this section would not be limited to developing water for export. Provision has also been made in each plan for reservoir releases to meet in-basin water requirements for fisheries preservation and Round Valley consumptive needs. The estimated water requirements used in these studies are preliminary and subject to considerable revision. However, they are considered sufficiently accurate for reconnaissance studies, and the availability of more refined data in the future should not significantly alter the plans.

Round Valley. The year 2020 Round Valley consumptive requirement was estimated to be 26,000 acre-feet per year. Reservoir releases of approximately 40,000 acre-feet per year would be made from Franciscan Dam. The irrigation return flows would pass down Mill Creek and into the lower reservoir.

Fisheries. The estimated requirement for fisheries is from a 1961 office report by Contract Service Biologists of the Department of Fish and Game. They estimated that releases of 54,000 acre-feet per year, together with some downstream channel improvements, would be sufficient to preserve the existing fisheries.

Related Studies

Studies by the Department of Water Resources. A study was made during this investigation to determine the most favorable means of providing water service to Round Valley. The projects which were studied are: a power diversion from Hulls Creek, a tributary of the North Fork Eel River; an independent Franciscan Dam and Reservoir; a Franciscan Dam and Reservoir with diversions from Williams Creek, and diversions from Spencer Reservoir. Any of these projects would be operated in conjunction with ground water development in Round Valley. Of the plans studied, the most favorable appears to be serving Round Valley as part of a major export plan. Releases to the valley would be made from Spencer Reservoir at Franciscan Dam.

Prior to initiation of the North Coastal Area Investigation, the Department studied this area under the planning program for The California Water Plan. The results of those studies were published in 1957 as Bulletin No. 3, which included a concept of how the water resources of each area might be developed for "optimum" use. The plan which was recommended for the Middle Fork Eel included the following features: water developed in a large Etsel Reservoir (lower site) would be released into a downstream Bell Springs Reservoir; the water would then be pumped up to Willis Ridge Reservoir for subsequent gravity diversion to the Sacramento Valley via Clear Lake. The plan set forth in Bulletin No. 3 assumes "ultimate development" and is not adaptable to staged construction.

Concurrent with the North Coastal Area Investigation, the Department has conducted a statewide program originally called the Water Requirements and Project Staging Program and now designated the Coordinated Statewide Planning Program. One objective of these studies has been to determine the projected future requirements for water in each hydrographic area of the North Coastal area. The results of these studies will be used to insure that each local area, such as Round Valley, will be reserved all the water it needs to provide for its future development.

Studies by Federal Agencies. There are two recent studies by the Bureau of Reclamation related to the Middle Fork Eel River. The major one was reported in June 1963, in their publication "Eel River Division - A Reconnaissance Appraisal". In the plan set forth in the report they propose to provide water service to areas within the Eel River Basin, Russian River Basin, and North of San Francisco Bay from a system of physical works constructed in two stages. The first stage would include English Ridge Reservoir. The second stage would include conservation features on the Middle Fork with a pumped diversion to English Ridge Reservoir. Their plan for the Middle Fork would be comprised of Etsel Dam and Reservoir, Etsel powerplant, Jarbow Dam and Reservoir, Deep Hole Dam (Elk Creek) and Reservoir, and pumping plants from Jarbow to Deep Hole and from Deep Hole to Elk Creek Tunnel. This plan is very similar to Plan W presented earlier in this section.

The second study by the Bureau is a feasibility investigation of projects to provide water service to Round Valley. Various possibilities which the Bureau has investigated include: ground water development, a power diversion from Hull's Creek, an independent Franciscan Dam and Reservoir, a Williams Valley Dam and Reservoir pumping from the Middle Fork, and diversion from a major export project.

Studies by Others. The only major study of a planning nature, other than those mentioned above, was made by Bechtel Corporation in 1959 for Metropolitan Water District of Southern California. The purpose of the study was to formulate a reconnaissance plan for developing 2.1 million acre-feet of annual export yield. A number of alternative plans were studied. One of the most favorable consisted of a large Dos Rios Reservoir which inundated Round Valley.

Upper Main Eel River

Numerous plans for developing the unregulated flows of the upper main Eel River have been studied during the investigation. Some of the studies were directed towards possible development of the upper main Eel River in conjunction with the conveyance of water diverted from the Middle Fork Eel; other studies analyzed the possibility of developing only the upper main Eel, without Middle Fork imports. In either case, planning for the upper Eel is greatly influenced by the existing diversion of Pacific Gas and Electric Company. Summary Plates 1 and 18 present data on various plans which are discussed in this section.

Existing Development

The present development of the water resources of the upper main Eel River consists of two reservoirs, a diversion tunnel, and the 9,040-kilowatt Potter Valley Powerhouse, all owned and operated by the Pacific Gas and Electric Company. Van Arsdale Dam and Reservoir, with a capacity of 700 acre-feet, was constructed in 1907. Van Arsdale Dam serves to divert water from the Eel River through a 6,000-foot tunnel to the powerhouse penstocks. A 450-foot power drop is made from the tunnel to the powerhouse, which is located at the north end of Potter Valley on the East Fork of the Russian River. Scott Dam, which forms Lake Pillsbury, was constructed in 1921 to provide regulation of the Eel River runoff. Lake Pillsbury has a storage capacity of 93,700 acre-feet.

The annual diversions into Potter Valley have varied from 71,000 acre-feet in 1924 to 205,000 acre-feet in 1952, with the average being about

142,000 acre-feet. In April 1950, the Pacific Gas and Electric Company completed the enlargement of a restricted section of the diversion tunnel, thereby increasing the maximum rate of diversion to 345 cubic feet per second. This would not have increased the amount of water diverted during the extremely dry years such as 1924, but in an average year the diversion from Van Arsdale Reservoir would have been increased by approximately 25,000 acre-feet. Allowing for this increased diversion capability, the average flow through the tunnel would have been about 167,000 acre-feet annually.

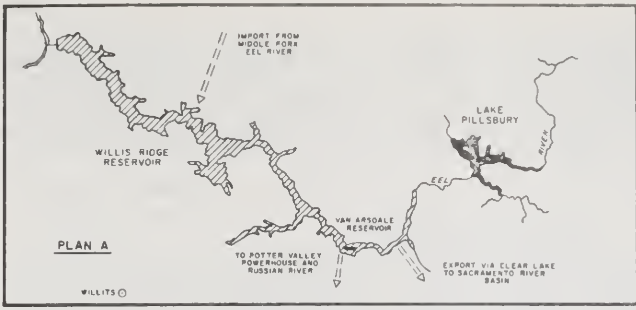
If a major water conservation project is constructed on the upper main Eel, negotiations with the Pacific Gas and Electric Company would be required to determine the disposition of their existing power development. The dependable capacity of the powerhouse would be greatly increased as the result of the uniform annual flows and by the increased head provided by the large reservoir on the Eel River. The existing plant is not, however, capable of generating at the increased capacity and would require modification or replacement.

Alternative Plans for Development

Numerous alternative plans for development of the upper Eel River have been studied during this investigation. On the basis of these studies four of the most promising plans involving export from the Middle Fork Eel have been selected. Two of these would consist of single reservoir developments which would not inundate Lake Pillsbury. They are Willis Ridge (Plan A) and English Ridge (Plan D). The other two, which would inundate Lake Pillsbury, each include two dams and reservoirs. They are: English Ridge and Benmore (Plan B) and English Ridge and Pressley (Plan C). These plans are shown on Figure 6.

All of these plans would develop water for local needs and export, and would reregulate and provide conveyance for flows diverted from the Middle Fork Eel River. The plan including Pressley Dam is the only one of the four with power features on the river. Power could be generated from the diversions into Potter Valley with all the plans.

Of the four plans, Plan A, with a large English Ridge Reservoir appears to be the most favorable development. English Ridge Reservoir with a storage capacity of 1,800,000 acre-feet at a water surface elevation of 1,695 feet would be formed by construction of a 535-foot high earth and

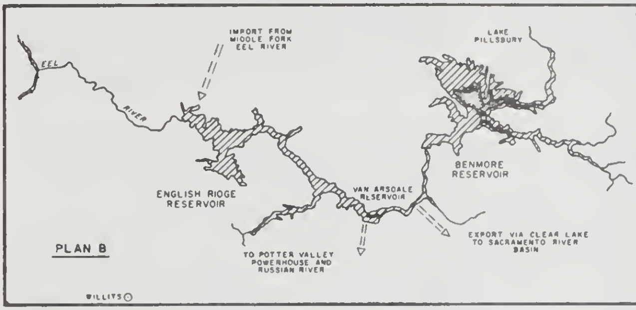


PLAN: Surplus water developed in Willis Ridge Reservoir would be diverted through Potter Valley Powerhouse into the Russian River Basin, or through Garrett Tunnel into the Sacramento River Basin.

DATA: Lake Pillsbury (existing)
Capacity: 93,724 acre-feet
Normal water surface elevation: 1817 feet

Willis Ridge Dam and Reservoir (proposed)
Capacity: 2,250,000 acre-feet
Normal water surface elevation: 1600 feet
Capital cost: $112,000,000
New yield from project: 265,000 acre-feet per year

DISCUSSION: This plan requires a relatively large inactive storage in Willis Ridge Reservoir, and thus reflects a higher annual unit cost of new yield than the English Ridge Reservoir alternate.

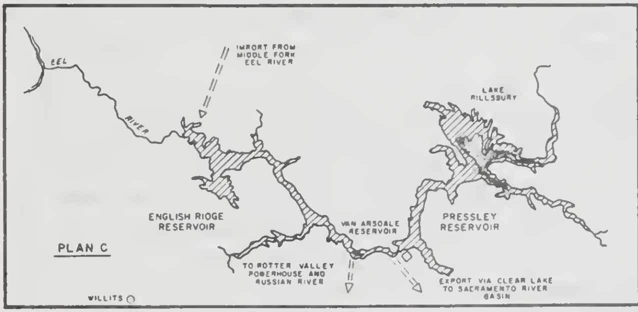


PLAN: Surplus water developed in English Ridge Reservoir would be diverted through the Potter Valley Powerhouse into the Russian River Basin, or through Garrett Tunnel into the Sacramento River Basin.

DATA: Benmore Dam and Reservoir (proposed)
Capacity: 955,000 acre-feet
Normal water surface elevation: 1960 feet
Capital cost: $33,000,000

English Ridge Dam and Reservoir (proposed)
Capacity: 1,300,000 acre-feet
Normal water surface elevation: 1610 feet
Capital cost: $65,000,000

New yield from project: 320,000 acre-feet per year



PLAN: Surplus water developed in English Ridge Reservoir would be diverted through the Potter Valley Powerhouse into the Russian River Basin, or through Garrett Tunnel into the Sacramento River Basin.

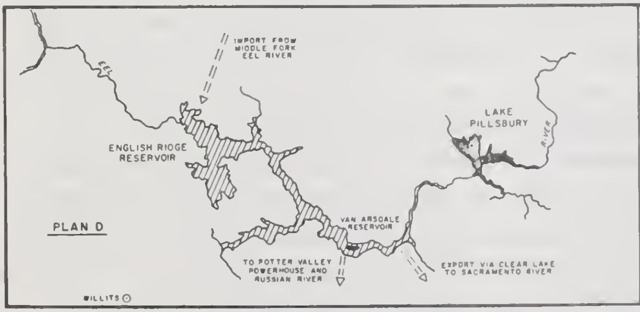
DATA: Pressley Dam and Reservoir (proposed)
Capacity: 1,500,000 acre-feet
Normal water surface elevation: 1985 feet
Capital cost: $71,000,000

Pressley Powerhouse (proposed)
Capacity: 42,000 KW
Capital cost: $8,000,000
Annual net revenue: $730,000

English Ridge Dam and Reservoir (proposed)
Capacity: 580,000 acre-feet
Normal water surface elevation: 1550 feet
Capital cost: $42,000,000

New yield from project: 300,000 acre-feet per year

DISCUSSION: See Plate 18



PLAN: Surplus water developed in English Ridge Reservoir would be diverted through the Potter Valley Powerhouse into the Russian River Basin, or through Garrett Tunnel into the Sacramento River Basin.

DATA: Lake Pillsbury (existing)
Capacity: 93,724 acre-feet
Normal water surface elevation: 1817 feet

English Ridge Dam and Reservoir (proposed)
Capacity: 1,800,000 acre-feet
Normal water surface elevation: 1695 feet
Capital cost: $81,000,000

New yield from project: 300,000 acre-feet per year

DISCUSSION: This plan would require the lowest capital investment and the lowest annual unit cost for the new water supply developed. See Plate Nos. 1 and 18.

ALTERNATIVE PLANS FOR DEVELOPMENT OF UPPER MAIN EEL RIVER

rockfill dam. This reservoir would develop a firm annual conservation yield of about 300,000 acre-feet, in addition to the present Eel River diversion into Potter Valley and in addition to downstream releases of 60,000 acre-feet annually.

North Fork Eel River

The North Fork Eel River Basin is typical of the Eel River drainages. The moderate to steep-walled canyons are interlaced with landslides and areas of heavy brush and trees. Geologically, the basin is located in the Franciscan formation where foundation conditions for proposed damsites are poor to fair.

At its confluence with the main Eel River, the North Fork has drained an area of 285 square miles. The 50-year (1911-60) mean annual runoff is 440,000 acre-feet. The one stream gaging station on the North Fork is located near the town of Mina, about 6 miles upstream from the confluence with the main stem. The drainage area at the gaging station is 251 square miles, and the 50-year (1911-1960) mean annual runoff is 374,000 acre-feet. The runoff at the gaging station provides the basis for estimated runoff at proposed damsites.

The primary purpose of a project on the North Fork Eel would be to conserve water for export. The ruggedness of the topography precludes development of an in-basin agricultural service area, and the remoteness and inaccessibility are not conducive to development of the recreation potential.

Alternative Plans for Development

These are two general ways in which runoff from the North Fork could be developed for export. One way would be to conserve the water in a reservoir on the North Fork and divert it by tunnel to the Middle Fork Eel River Basin, for subsequent diversion to the Sacramento Valley. The other way would be to conserve the water in a large reservoir on the lower Eel, along with other runoff into the Eel, and pump it upstream through an earlier constructed conveyance system to the Sacramento Valley. No development on the North Fork would be required in the second plan.

Although both ways of developing the North Fork were studied during this investigation, most of the studies were directed toward examination of a gravity diversion to the Middle Fork Eel River Basin. The conservation feature in this plan would be Upper Mina Dam and Reservoir. The dam would be located on the North Fork Eel River about one-half mile below the confluence with Hulls Creek. Preliminary designs indicate that the dam would be of earthfill construction. The maximum height of dam considered at this site is 420 feet. The site has not been drilled. Although difficult foundation problems are anticipated, surface geology indicates that the site is adequate for the heights of dam considered.

The surplus water conserved in Upper Mina Reservoir would be diverted by gravity through Hulls Creek Tunnel. The tunnel would extend from an arm of Upper Mina Reservoir on Hulls Creek a distance of about 9 miles to Williams Valley, an arm of Spencer Reservoir on the Middle Fork Eel River. The head necessary for flow through the tunnel would be provided by maintaining Upper Mina Reservoir at a higher level than Spencer Reservoir.

Analysis of this plan indicates that the most favorable development would consist of an Upper Mina Reservoir; gross capacity 320,000 acre-feet, and a Hulls Creek Tunnel, 10 feet in diameter. By utilizing 210,000 acre-feet of active storage in Upper Mina Reservoir, an average of 230,000 acre-feet of yield could have been diverted to Spencer Reservoir during the historical 1916-1934 critical period. The estimated capital cost of this plan is approximately $80 million, $57 million of which is in Upper Mina Dam. The average unit cost of the water delivered to Spencer Reservoir would be about $17.50 per acre-foot.

Pumped Diversion. An alternate plan of diversion would be to pump from a lower level reservoir on the North Fork Eel River to a gravity flow tunnel extending to Spencer Reservoir. The lower reservoir would be formed by a dam located about 4 miles downstream of the Upper Mina site. The pumping plant and tunnel intake would be located in Bear Canyon, a tributary to the North Fork.

Analysis indicates that the most favorable plan of development would consist of Mina Dam and Reservoir, gross capacity 420,000 acre-feet, a pumping plant, and a tunnel 8 feet in diameter and 8 miles long. With an active storage of 320,000 acre-feet in Mina Reservoir, approximately 230,000 acre-feet of yield would be developed. A 12,000 kilowatt capacity pumping plant would lift this water about 380 feet to the tunnel invert, where it would flow by gravity to Williams Valley. The estimated capital cost of this plan is about $62 million, $40 million of which is in Mina Dam. The average unit cost of this water is about $16.50 per acre-foot.

Conclusions. The foregoing reconnaissance analysis indicates that if the flows from the North Fork Eel are to be developed with a project in the basin, a plan using pumped diversion is probably more economical than one using gravity diversion. However, as mentioned in the introduction it may be better to develop the North Fork flows in a lower Eel River reservoir and pump the yield upstream. In any event, the comparatively high unit cost of yield from a North Fork project indicates that it should not be considered as a probable early stage project.

Related Studies

Mad-Van Duzen Diversion to North Fork Eel. A very rough reconnaissance study was made of a plan to divert surplus flows of the Mad and Van Duzen Rivers to Upper Mina Reservoir on the North Fork Eel River. The plan would include construction of a small diversion dam on the Van Duzen River, a tunnel to an enlarged Ruth Reservoir on the Mad River, a tunnel to the North Fork Eel, and a powerplant upstream of Upper Mina Reservoir.

Construction of Lassic Dam on the Van Duzen River, immediately downstream of Red Lassic Creek, would permit gravity diversion of natural river flows through a tunnel into an enlarged Ruth Reservoir. This water, together with that conserved in Ruth Reservoir, would be routed through a tunnel and powerplant into Upper Mina Reservoir. The water then would be diverted to the Middle Fork Eel River. Butler Valley Dam and Reservoir would be constructed on the lower Mad River to develop a water supply to replace that now being developed in Ruth Reservoir.

On the basis of this study, approximately 230,000 acre-feet of new water yield could be developed on the Mad and Van Duzen Rivers and diverted to the North Fork Eel River for a capital outlay of about $60 million. Over 800 feet of power head could be developed between Ruth Reservoir and Upper Mina Reservoir.

A comparison of the above plan with alternative plans for routing yield from the Mad and Van Duzen Rivers via the Trinity River shows that the above plan is probably more costly. Therefore, no further consideration is being given to it at this time.

Bulletin No. 3. The California Water Plan, presented in Bulletin No. 3, included a small reservoir on the North Fork Eel River at the Caution site. It was envisioned that the 12,000 acre-foot capacity reservoir would be a local project to provide for recreation and fisheries enhancement. No further studies of the project have been made.

CHAPTER III

CACHE AND PUTAH CREEK BASINS

During the North Coastal Area Investigation, the Cache and Putah Creek Basins were studied as possible links in the conveyance system for diverting surplus Eel River water to the Sacramento-San Joaquin Delta. Both basins have previously been the subjects of individual investigations directed exclusively towards in-basin development. Bulletin No. 90, Clear Lake-Cache Creek Basin Investigation, published in March 1961, presented a comprehensive plan for development of the basin. Bulletin No. 99, reconnaissance report on Upper Putah Creek Basin Investigation, published in March 1964, presented possible plans for development of the water resources of that basin.

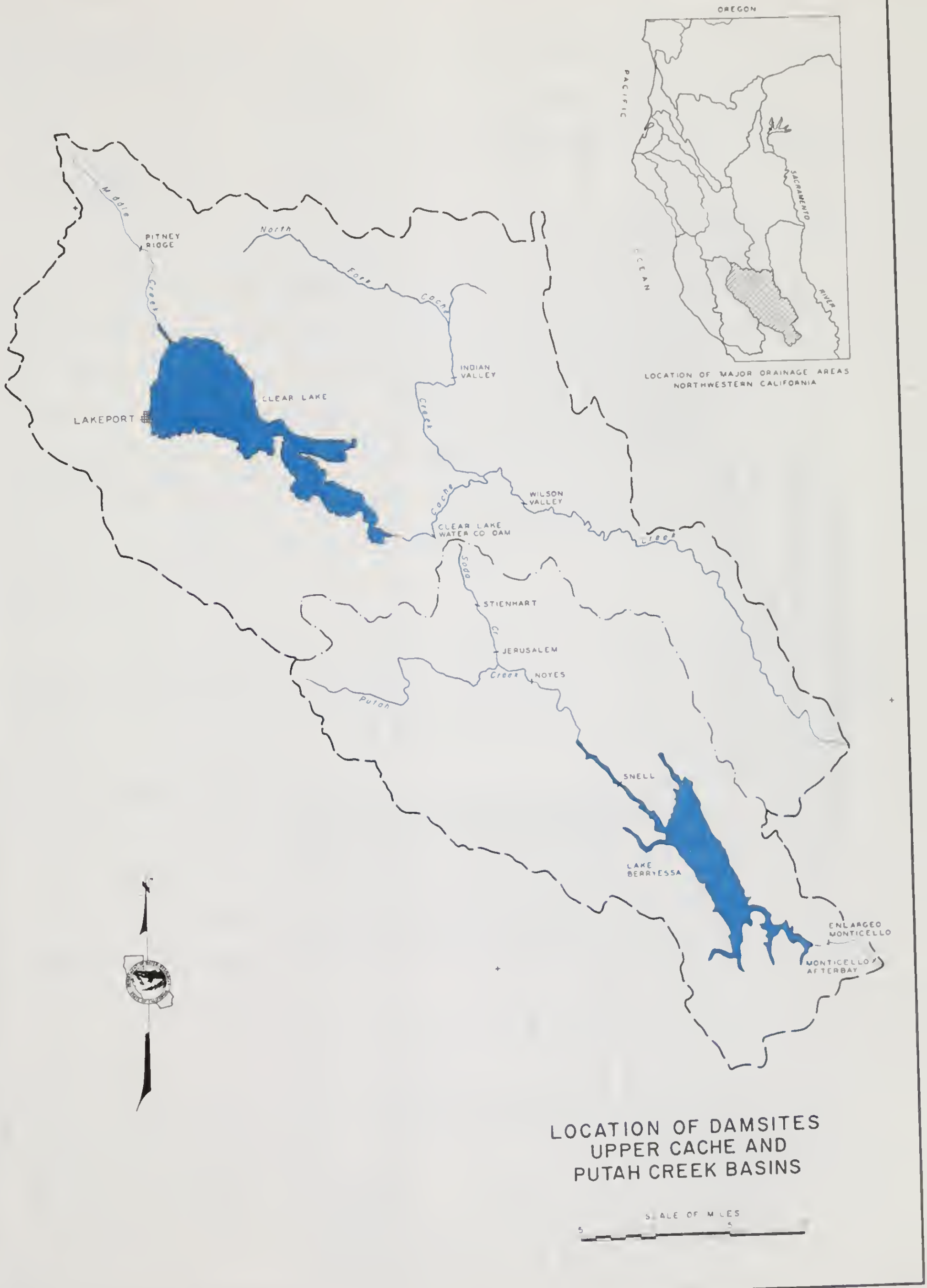
The drainage boundaries, stream pattern, general orientation of these basins and damsite locations are shown on figure 7.

Clear Lake-Cache Creek Basin

Water developed on the Eel River and diverted through a tunnel into the Clear Lake-Cache Creek Basin would enter the basin in the drainage area above Clear Lake. It would flow through Clear Lake and then would either pass down Cache Creek or would be diverted through a tunnel into the Putah Creek Basin, for reregulation in Lake Berryessa. Summary Plates 6 and 6A present data on possible conveyance systems through the two basins. In the following sections the various conveyance features are discussed.

Eel River-Clear Lake Transbasin Conveyance

The Eel River and Clear Lake drainage basins have a common drainage boundary about 20 miles in length, with the mountains rising to an elevation of over 4,000 feet. There are two alternative routes for accomplishing the transbasin diversion: either by a long tunnel connecting the two basins, or



LOCATION OF DAMSITES
UPPER CACHE AND
PUTAH CREEK BASINS

SCALE OF MILES

TABLE 3

CACHE AND PUTAH CREEK BASINS

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Pitney Ridge	Middle Creek	S. 25 T16N R10W MDB&M	50	45	1,405	Power recovery feature, previously named Hunter Point
Clear Lake Dam	Cache Creek	S. 6 T12N R6W MDB&M	492	263	1,300	Existing control structure for Clear Lake
Wilson Valley	Cache Creek	S. 19 T13N R5W MDB&M	765	418	867	Multipurpose local project and possible export feature
Blue Ridge	Cache Creek	S. 6 T12N R4W MDB&M			650	Possible power recovery feature
Guinda	Cache Creek	S32&33 T12N R3W MDB&M			380	Possible local project
Stienhart	Soda Creek	S. 27 T12N R6W MDB&M	19	8	1,045	Possible power recovery feature
Jerusalem	Soda Creek	S. 14 T11N R6W MDB&M	29	12	900	Possible power recovery feature
Noyes	Putah Creek	S. 30 T11N R5W MDB&M	181		660	Possible power recovery feature
Snell	Putah Creek	S30&31 T10N R4W MDB&M	270		360	Possible power recovery feature
Monticello	Putah Creek	S. 29 T8N R2W MDB&M	568	340	185	Existing USBR Solano Project
Enlarged Monticello	Putah Creek	S. 28 T8N R2W MDB&M	577	345	180	Possible major conservation facility
Monticello Afterbay	Putah Creek	S. 36 T8N R2W MDB&M			140	Possible pumping forebay & power afterbay
Davis Pump Lift	Putah Creek	S. 19 T8N R2E MDB&M			40	Pump-lift for imports from Sacramento River to Monticello

by a system including a short tunnel into Potter Valley, a canal around the valley, and a short tunnel into the Clear Lake Basin. The Department's studies show that a tunnel through Garrett Ridge would be the most practical and reliable means of diversion.

Garrett Tunnel would convey water from English Ridge Reservoir to Middle Creek, a tributary of Clear Lake. Numerous combinations of active storages in English Ridge Reservoir and various elevations and alignments of Garrett Tunnel have been analyzed. These studies indicate that the most favorable intake elevation of the tunnel would be 1,500 feet. The corresponding outlet elevation in Middle Creek would be 1,450 feet. The tunnel would be about 14 feet in diameter and 12.2 miles long. The estimated capital cost of Garrett Tunnel is $55 million.

Middle Creek

Studies were made of the possibility of developing the power head between the upper Main Eel River and Clear Lake. One of the more favorable plans include the construction of Pitney Ridge Dam and Powerplant on Middle Creek. These studies indicated that the power development probably could not be justified unless annual diversions from the Eel River were in excess of 800,000 acre-feet. In addition, operation of the power facilities would detract from the possible benefits from coordinated water operation of English Ridge Reservoir and Clear Lake. For these reasons, the Middle Creek power development is not proposed as part of The Upper Eel River Development.

Clear Lake

Clear Lake is a large shallow natural body of water with a gross capacity of about 1,100,000 acre-feet, and a surface area of 43,000 acres at water surface elevation 1,325 feet. The maximum depth is about 50 feet. In

1914, a 32-foot-high concrete gravity dam was constructed about three miles downstream from the lake on Cache Creek to provide regulation of the stored water. In 1927 this dam and the water rights of the former owners were acquired by the Clear Lake Water Company, which has been operating the system since that time.

The Clear Lake Water Company provides irrigation water service to Yolo County. The diversions from Cache Creek are developed from water released from Clear Lake combined with unregulated runoff. These diversions average about 100,000 acre-feet annually. However, the amount of water available in Cache Creek for diversion is quite variable and the annual diversions have ranged from a low of 13,000 acre-feet in 1931 to 189,000 acre-feet in 1946. The annual diversion during the period 1929-1934 inclusive, averaged 45,000 acre-feet.

Clear Lake is operated under terms of the Gopcevic Decree, which was rendered October 7, 1920. Under this decree the Clear Lake Water Company is permitted to fluctuate the lake between the limits of zero and 7.56 feet on the Rumsey Gage, which is located near the edge of the lake at Lakeport. These gage heights correspond to water surface elevations 1,318.59 and 1,326.15 feet respectively. Within these limits the lake has a storage capacity of about 314,000 acre-feet.

Water from Clear Lake flows through an extremely narrow and shallow outlet channel before it is released into Cache Creek from the Clear Lake Water Company Dam. The outlet channel has a capacity of approximately 2,500 second-feet with the water level of Clear Lake at 1,326.15 feet. This is insufficient to pass the runoff that accumulates in the lake during periods of excessive flood inflow from tributary streams. Consequently, during periods of excessive runoff, the lake level rises and extensive flood damage occurs to land and improvements adjacent to the lake. Under the terms of the Bemmerly

Decree rendered December 18, 1940, as the result of litigation brought by downstream interests, the outlet channel cannot be enlarged to pass waters from the lake at an increased rate of flow. The downstream residents were concerned about additional flooding of their property, should additional water be added to the flow of Cache Creek during flood stage.

Under operation of the Upper Eel River Development, Clear Lake would not be allowed to fluctuate as widely as it does at present. The enlarged outlet channel and the Soda Creek Tunnel would have sufficient capacity to pass the flood waters which normally damage areas adjacent to the lake. The tunnel would have sufficient capacity to convey water needed to satisfy the local demands of Upper Putah Creek and the power demands of the Soda Creek power facilities.

The enlargement of the Clear Lake outlet channel and the modification of the operation of Clear Lake, as described, would necessitate modification of the Gopcevic and Bemmerly Decrees. However, the desired flood protection and the improved water supply conditions created by the Eel River imports should warrant the required modification of these decrees. Under the modified operation the Clear Lake Water Company would not be required to increase the releases to Cache Creek during flood periods over what would normally be released under their present operation.

Wilson Valley Dam and Reservoir

A dam and reservoir at the Wilson Valley site on Cache Creek was proposed in Bulletin No. 90 as a development to serve water requirements in the Cache Creek Basin. It is recognized that a large reservoir at this site could also provide reregulatory storage for water imported from the Eel River. Although this possibility has received only cursory study to date, it will be investigated in detail in the advance planning studies for the Upper Eel

River Development. It is envisioned that a reservoir to meet local and reregulatory needs would be as large as the site permits, probably over 1.5 million acre-feet of storage.

Putah Creek Basin

Soda Creek Tunnel

Soda Creek Tunnel would connect the Clear Lake Basin with the Upper Putah Creek Basin. The tunnel would be sized to convey flows required for generation of peaking power at Stienhart Dam, the uppermost of the Upper Putah Creek Basin power features. The capacity of the tunnel would be sufficient to enable the diversion of essentially all flood flows from the Clear Lake Basin. The tunnel would be about 19 feet in diameter and 2 miles long.

Stienhart Reservoir and Powerplant

Stienhart Dam and Reservoir would be constructed primarily for power generation on Soda Creek, a tributary of Putah Creek. The earth and rockfill dam would have a height of 275 feet and a crest length of 850 feet. The reservoir site has a natural drainage area of 19 square miles and an estimated mean annual natural runoff of 7,000 acre-feet. The gross capacity of the reservoir would be 80,000 acre-feet, with a water surface area of 850 acres at a normal water surface elevation of 1,300 feet. A powerplant located at the toe of Stienhart Dam would develop about 250 feet of head. With an annual diversion of 500 acre-feet from the Eel River, the powerplant would have a capacity of 47,000 kilowatts.

Jerusalem Reservoir and Powerplant

Jerusalem Dam and Reservoir would also be constructed on Soda Creek for the primary purpose of power generation. The earth and rockfill dam would have a normal water surface elevation of 1,045 feet, a gross capacity of 46,000 acre-feet, and a surface area of 750 acres. The drainage area between Stienhart and Jerusalem damsites is 10 square miles and the estimated mean annual runoff between the two damsites is 5,200 acre-feet. A powerplant located at the toe of Jerusalem Dam would develop about 240 feet of head by excavation of a tailwater channel. The material from the tailwater excavation would be used as fill material for Jerusalem Dam. With an annual diversion of 500,000 acre-feet from the Eel River, Jerusalem Powerplant would have a capacity of 42,000 kilowatts.

Both Stienhart and Jerusalem Reservoirs would be maintained at or near their normal pool elevations. These reservoirs would therefore have no water conservation or flood control benefits, but would provide good areas for recreation.

Solano Project

Lake Berryessa, the key storage feature of the U. S. Bureau of Reclamation's Solano Project, was completed in 1955. At its normal water surface elevation of 440 feet the lake has a gross storage capacity of 1.6 million acre-feet and a surface area of 19,250 acres. The reservoir can develop an annual irrigation supply of 247,000 acre-feet. The project provides water to Solano County through the Putah South Canal which extends from the diversion dam on Putah Creek, about 6 miles below Monticello Dam, a distance of 38 miles southwest to the vicinity of Cordelia.

The recreation development which has taken place around Lake Berryessa has been explosive. There are seven large recreational developments on the west shore of the lake and more are planned. The U. S. Bureau of Reclamation has reserved a perimeter strip approximately 300 feet wide around the entire lake. Napa County has been granted a permit to use this land and has in turn subleased to private parties for the development of public resorts and parks. These leases run from 20 to 50 years and contain restrictions as to the construction, operation, and types of facilities permitted. The improvements revert back to the county at the termination of the lease.

Enlarged Lake Berryessa

An enlarged Lake Berryessa would be strategically located to provide for reregulation of imported water from the Eel River and to provide for storage of flood flows pumped from the Sacramento River. Reconnaissance studies indicate that a large pumped storage power generation installation could be included in the Greater Berryessa Project. Summary Plate No. 7 presents data on possible plans for an enlarged Lake Berryessa, involving a pumped storage operation with flows from the Sacramento River only.

Preliminary studies indicate that the optimum capacity of an enlarged Lake Berryessa would be approximately 14 million acre-feet. The lake would have a water surface area of 65,600 acres at its normal pool elevation of 760 feet. The lake would be formed by construction of a 590-foot high earth and rockfill dam on Putah Creek approximately one mile downstream of the existing Monticello concrete arch dam. During construction the existing lake would continue its normal operation.

Conveyance Facilities to Sacramento River. Extensive conveyance facilities would be required between Lake Berryessa and the Sacramento River. These facilities would enable the diversion of flood flows from the Sacramento River to the lake, the operation of the pumped storage installation, and the conveyance of water from the lake to the Sacramento River.

The pumped diversion from the river would require a siphon under the deep water ship channel, two afterbay dams, two low-head pumping plants, and the channelization of Putah Creek. A pump-turbine plant would be installed at the enlarged Monticello Dam. A low head pumping plant would also be required to lift water from the Putah Creek channel into the Sacramento River. The connection on the Sacramento River would be located approximately 7 miles southwest of Sacramento, upstream of the diversion point of the proposed peripheral canal around the Sacramento- San Joaquin Delta.

Pumped Storage Operation. The pumped storage operation of the Greater Berryessa Project would be similar to the pumped storage operation at Oroville Dam. The water would be lifted from Monticello Afterbay into the enlarged Lake Berryessa during "off-peak" hours by reversible pump-generating units. During "on-peak" hours water would be released back into the afterbay, and power would be generated by the reversible units. The proposed plant would have a pumping capacity of 450 megawatts and a generating capacity of 240 megawatts.

Reservoir Filling. One of the major considerations in the Greater Berryessa Project is filling the large lake to a safe operating level prior to its initial operation. In order to compare this project with other alternatives the cost was modified to reflect the interest on the investment and the operating costs incurred during the filling period. The assumptions leading to the cost modification are as follows:

The reservoir would have a annual storable inflow of approximately 1,500,000 acre-feet from the Eel River, Putah Creek, and Sacramento River during years of normal runoff. Assuming 1,000,000 acre-feet in the existing reservoir, and normal runoff occurring, a total of 7,000,000 acre-feet would be in storage within four years. This would be an adequate amount of storage prior to full project yield deliveries. The capitalized cost of interest plus the net pumping and operating costs during this period would be about $60,000,000. It was assumed that power generation would begin during "on-peak" hours when the reservoir reaches its minimum pool elevation. When allowing for the initial filling cost, the total capital cost of the project would be about $311,000,000.

CHAPTER IV

WEST SIDE SACRAMENTO VALLEY

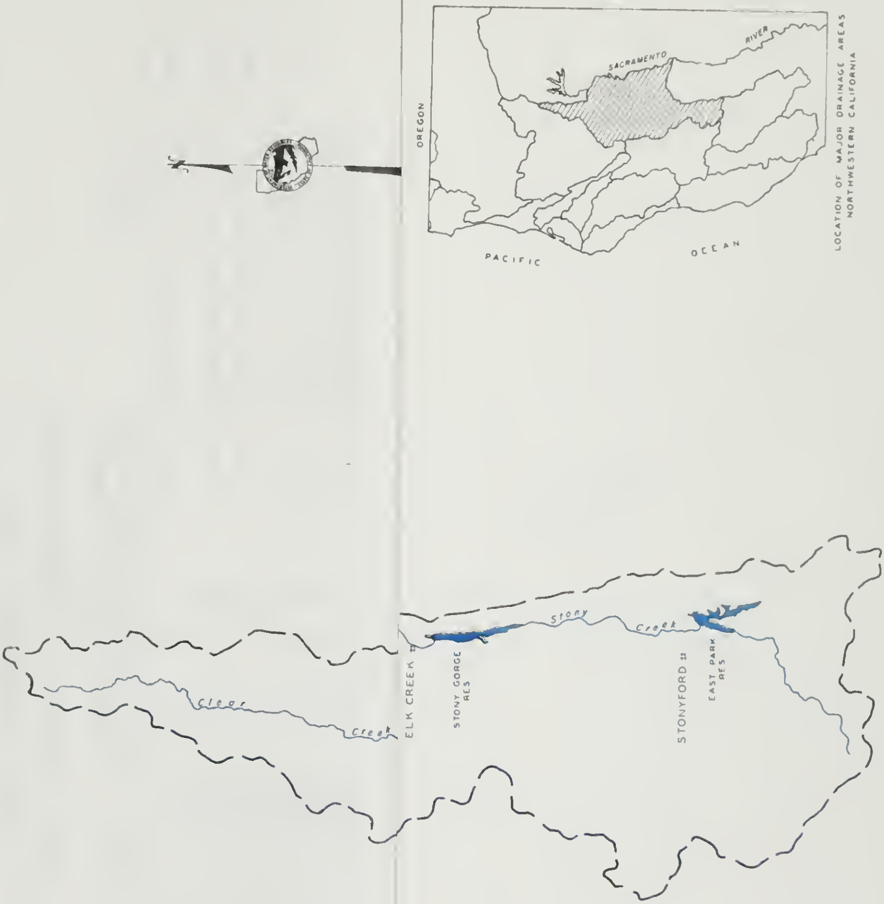
Stony, Thomes, Elder, Cottonwood, and Clear Creek Basins

There are several possible major projects on the west side of the Sacramento Valley which could be associated with imported water from the North Coastal area. These include the Glenn Reservoir Complex, the West Side Conveyance System, and power development features on Clear Creek. The drainage boundaries, stream pattern and damsite locations are shown on Figure 8. Pertinent hydrographic and topographic data for the damsites is given in Table 4.

In the course of this investigation the operation and accomplishments of these reservoir systems were analyzed for a number of assumed conditions in several alternative physical plans. These studies and the alternative plans are discussed in this chapter.

Glenn Reservoir Complex - A General Description

The Glenn Reservoir Complex would consist of three adjacent reservoir units located in the foothills on the west side of the Sacramento Valley in Glenn and Tehama Counties. The reservoir area lies between the Northern Coast Range of Mountains on the west and a low narrow ridge on the east, called Rocky Ridge. The North Fork of Stony Creek cuts through Rocky Ridge at Newville damsite. Stony Creek cuts through low hills of this same formation about 8 miles to the south at Rancheria damsite. Paskenta Reservoir, which would be the northern element of Glenn Reservoir Complex, would be located on Thomes Creek. These damsites are shown in Figure 8.



LOCATION OF DAMSITES
WEST SIDE SACRAMENTO VALLEY
STREAM BASINS

SCALE OF MILES
5 0 5 10

LOCATION OF DAMSITES
WEST SIDE SACRAMENTO VALLEY
STREAM BASINS

TABLE 4

WEST SIDE SACRAMENTO VALLEY

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Towerhouse	Clear Creek		154	174	1,220	Hydroelectric facility-N. Coast imports
Kanaka	Clear Creek	S. 22 T31N R6W MDB&M	218	246	700	Hydroelectric facility-N. Coast imports
Saeltzer	Clear Creek	S. 31 T31N R6W MDB&M	236	266	550	Hydroelectric facility-N. Coast imports
Girvan	Clear Creek	S. 26 T31N R5W MDB&M	245	276	445	Hydroelectric facility-N. Coast imports
Selvester	M.F. Cottonwood	S. 31 T31N R6W MDB&M	108	72	1,025	Hydroelectric facility-N. Coast imports
Fiddlers	M.F. Cottonwood	S. 33 T29N R7W MDB&M	208	132	760	Northernmost feature of Westside conveyance system
Westside Conveyance System						Damsite data is shown on Plate No. 12
Paskenta	Thomes Creek	S. 6 T23N R6W MDB&M	188	200	790	Unit of Glenn Complex; possible local project
Newville	N.F. Stony Cr.	S. 3 T22N R6W MDB&M	55	15	600	Unit of Glenn Complex; possible local project
Rancheria	Stony Creek	S. 14 T21N R6W MDB&M	601	412	580	Unit of Glenn Complex
Julian Rocks	Stony Creek	S. 1,12 T21N R6W MDB&M	611	419	550	Alternative site to Rancheria
Black Butte	Stony Creek	S. 29 T23N R4W MDB&M	741	459	380	U.S.C.E. Fl. Control; water cons.; completed 1963
Stony Gorge	Stony Creek	S. 16 T20N R6W MDB&M	299	254	727	USBR Orland Project; completed 1928
East Park	Little Stony Creek	S. 3 T17N R6W MDB&M	102	56	1,112	USBR Orland Project; completed 1910

Purpose of Development

The Glenn Reservoir Complex is potentially one of the most favorable major water developments in the State. Although the unregulated tributary inflow is relatively small, the complex is favorably located to accomplish reregulation of imported water from the North Coastal area. The complex could also provide long-term carryover storage, which would improve coordination within the Central Valley reservoir system. Although the complex would be operated primarily for releases to the Sacramento-San Joaquin Delta, water would also be provided for domestic use, local irrigation, fisheries enhancement, and recreation. In addition to its favorable location, the unit cost of this large reservoir storage compares favorably with any other site in the Central Valley, with the possible exception of an enlarged Lake Berryessa.

The complex offers a unique opportunity for possible staging. There are innumerable possible physical combinations among dam sizes, saddle dams, and interconnecting channels to develop any desired storage capacity or to increase capacity at some future time after initial construction. Not only could the individual dams be raised in elevation at some future date to increase storage capacities of their respective reservoirs, but each component reservoir could be integrated into the complex by replacing the low saddle dam near Chrome, initially required to separate the reservoirs, with a connecting channel.

Description of Area

The reservoir area is located in rolling grass-covered hill land. The area is clear except for scattered trees and brush, mainly along the water courses. The community of Elk Creek with a population of about 150, and scattered farms and rural areas, with a total population of about 175, are located in the proposed reservoir area. The only industrial development in the area is a sawmill located near Elk Creek. Agricultural lands within the proposed reservoir area are relatively unproductive, consisting primarily of open-range grazing lands. A north-south county road traverses the entire length of the reservoir area. The existing Stony Gorge Dam and Reservoir would be inundated by the Rancheria Reservoir component.

Related Studies

A dam and reservoir at the Paskenta site on Thomes Creek has been considered as a possible local development by both state and federal agencies. The Tehama County Flood Control and Water Conservation Association considered construction of Paskenta Dam with possible financial assistance from the State under the Davis-Grunsky program. The Department also studied Paskenta Reservoir under the Upper Sacramento River Basin Investigation. The possibility of constructing Paskenta Dam as part of a larger Paskenta-Newville Reservoir Project is discussed later in this chapter.

A dam at the Newville site was included in the plan presented in Bulletin No. 3. The proposed 950,000 acre-foot reservoir would regulate spills from Paskenta Reservoir and would conserve water diverted from Grindstone Creek. It would be operated in conjunction with Stony Gorge Reservoir of the Orland Project to accomplish additional regulation of Stony Creek. The Rancheria site on Stony Creek, located about 3 miles upstream has not previously been given consideration.

Existing Developments

There are three existing reservoirs on Stony Creek. East Park Reservoir, with a capacity of 51,000 acre-feet, is located on Little Stony Creek near the community of Stonyford. It was constructed in 1910 by the U. S. Bureau of Reclamation as part of the Orland Project. Stony Gorge

Reservoir, with a capacity of 50,200 acre-feet, is located on Stony Creek near the community of Elk Creek. It was constructed by the Bureau in 1928 as an addition to the Orland Project. Black Butte Reservoir, with a capacity of 160,000 acre-feet is located on Stony Creek about 9 miles upstream of the town of Orland, and was constructed by the Corps of Engineers in 1963. Although the reservoir will be operated primarily for flood control, it will also provide an additional firm water supply from Stony Creek.

Glenn Reservoir Complex with Imports from Middle Fork Eel River-Studies for Plate No. 3

The concept of using the Glenn Reservoir Complex to reregulate water from the North Coastal area was first considered in connection with imports from the Middle Fork Eel River. It was recognized that one way to get around the lack of large, cheap storage on the Middle Fork (other than flooding Round Valley) and to keep the size of the diversion tunnel to a minimum would be to divert the runoff on an "as-available" schedule. The entrance to the diversion tunnel would be set low in the reservoir so that when high runoff caused the reservoir to fill, a high gravity head would be acting to divert the water through the tunnel. Thus, the annual rate of diversion would correspond to wet and dry cycles of runoff and during extremely dry periods little or no water would be diverted.

The studies summarized on Plate 3 were made to determine the relationship between new yield and the physical project parameters of a plan utilizing the above concept. To provide a base for reference, the Glenn Complex was first analyzed as an individual project with no imports. A range of imports from the Middle Fork was then added to the Glenn tributary inflow to evaluate the new yield of the entire plan.

The estimates of firm annual yield from the project are based on reregulating the imports and local flows to a uniform release schedule. This is probably not the release schedule Glenn Reservoir would operate on for efficient coordination with the Delta and other Central Valley reservoirs. However, it provides a convenient basis for comparison of projects, and is sufficient for that purpose.

At the time the studies were made, Spencer and Jarbow Reservoirs were considered to be the most favorable alternative conservation features on the Middle Fork. In the studies they were operated for a range of reservoir capacities and tunnel diameters. The operations provided water for Round Valley and for fisheries purposes and provided for diversion of the surplus flows on the schedule described above. During subsequent studies it was determined that Dos Rios Reservoir would probably be cheaper, hence more favorable, than Jarbow Reservoir.

The more significant information shown on Plate 3 includes (1) relationships between active reservoir storage on the Middle Fork Eel River and surplus water which can be diverted to Glenn Reservoir through various size tunnels; (2) storage-yield relationships for combinations of units of Glenn Reservoir, with and without Eel River diversions; and (3) comparison of annual unit cost of new yield from various combinations of Glenn Reservoir, evaluated with diversions from either Jarbow Reservoir, capacity 285,000 acre-feet, or Spencer Reservoir, capacity 532,000 acre-feet.

On the basis of information presented on Plate 3, the combination of a 532,000 Spencer Reservoir, a 10-foot diameter Thomes Creek Tunnel, and a Paskenta-Newville Reservoir, represents the most favorable project of those studied. This plan of development was presented in

Bulletins 132-63 and 132-64, the State Water Project, as the initial facilities to be constructed in the North Coastal area.

Hydroelectric Power Potential Associated with Glenn Reservoir

Power Potential Between Middle Fork Eel River and Glenn Reservoir

Studies were made to determine the feasibility of developing the power potential between the Middle Fork Eel River and Glenn Reservoir. The alternative plans which were investigated are: (1) gravity diversion from either Spencer or Etsel Reservoir through a tunnel designed for daily peaking operation, with a powerplant located in Grindstone Canyon; (2) gravity diversion from either Spencer or Etsel Reservoirs through a tunnel designed for monthly peaking operation, to a small reregulating reservoir on Grindstone Creek, with a powerplant located at base of Grindstone Dam.

The results of these studies showed that in all cases the unit cost of water delivered to Glenn Reservoir was greater with power development than without it. There are two physical factors which are adverse to power development. One is the extremely long (19 to 20 miles) tunnel required to divert Middle Fork Eel water to Grindstone Creek. The other is the lack of reservoir sites on Grindstone Creek. The cost of constructing a long tunnel large enough for peaking operation is so much greater than the cost of a tunnel designed for nonpeaking operation that the additional cost more than off-sets potential net power revenues. In the plan with a nonpeaking tunnel, the cost of storage on Grindstone Creek of sufficient capacity to reregulate Middle Fork Eel flows to a peaking power schedule is also greater than the potential net power revenues.

On the basis of these studies, the inclusion of power features above Glenn Reservoir is not justified in the plans of diverting water from the Middle Fork Eel River to Glenn Reservoir. However, the possibility should be reconsidered in the advance planning studies. Perhaps a power development would appear more favorable if it were coordinated with other possible power developments below Glenn Reservoir.

Power Potential Between Glenn Reservoir and Sacramento River

Numerous studies have been made to determine the most favorable plan for developing the power potential between Glenn Reservoir and the Sacramento River. Of the many plans which have been studied, the one including powerplants at Newville, Black Butte and Sour Grass Dams appears the most promising. Kirkwood Reservoir would function as a reregulating afterbay. Approximately 650 feet of power head can be developed by this system.

These studies were based on the assumption that Glenn Reservoir would not be operated to firm flows in the Sacramento-San Joaquin Delta but instead would release water to the Sacramento River on a uniform power schedule. Under a firming type operation, the power production would be greatly reduced.

Pertinent conclusions from the studies are: (1) power developments are not economical with flows from either an individual Paskenta-Newville Reservoir or with these flows plus those from the West Side Conveyance System; (2) they might be economical with imports from either the Middle Fork Eel River or the Trinity River or both. When more information on the future value of hydroelectric power and on operational requirements for Delta coordination become available, more definitive studies of Glenn Reservoir power potential can be made.

Coordinated Operations of Glenn and San Luis Reservoirs

One of the most difficult problems during this investigation has been to determine how the operation of Glenn Reservoir would be coordinated with other reservoirs in the Central Valley system. To gain a better understanding of this relationship, a coordinated operation of Glenn and San Luis Reservoirs was programmed for the I.B.M. 650 computer in 1960. Numerous studies were made with the computer to determine the additional yield available from San Luis Reservoir, when operated coordinately with Glenn Reservoir. Inflow to Glenn Reservoir was varied to reflect different combinations of diversions from the Middle Fork Eel River, West Side Conveyance System, and the Trinity River. The effects of the other reservoirs in the Sacramento Valley system were included as modifications to the water supply available to San Luis Reservoir from the Sacramento-San Joaquin Delta. The results of the studies indicated the importance of operating large firming storage, such as Glenn, in coordination with San Luis Reservoir.

Subsequent to these studies, a new and more comprehensive operational program has been written for San Luis Reservoir by the Divisions of Resources Planning and Operations. This program, which is part of the new master program for coordinated operation of all major reservoirs in the Central Valley, supersedes all previous studies. It is anticipated that future projects such as Glenn Reservoir will be included in the program, so that their merits can be more accurately evaluated. Until these future projects are included in the master program, approximate methods must be used to determine new Delta yield attributable to them.

Paskenta-Newville Project

In addition to the studies made of the Paskenta Project in relation to Tehama County's Davis-Grunsky application, a study was made to determine the merits of a Paskenta-Newville Reservoir. This project would be constructed and operated to develop the flows of Thomes and North Fork Stony Creeks. On the basis of this analysis, it appears that the project would be justified and should be considered as a possible early addition to the State Water Resources Development System.

Description

The Paskenta-Newville Reservoir Project would have a total storage of about 1,200,000 acre-feet. The project would consist of two reservoirs with a connecting spillway channel between them. Paskenta Reservoir on Thomes Creek would have a gross storage capacity of about 70,000 acre-feet at a normal water surface elevation of 965 feet. Newville Reservoir would have a gross storage capacity of 1,130,000 acre-feet at a normal water surface elevation of 845 feet.

Operation

Paskenta Reservoir would be operated to provide water for local irrigation and for fisheries enhancement on Thomes Creek. Spills from the reservoir would be diverted by the channel spillway into Newville Reservoir. The runoff to Thomes Creek is so great, in relation to the storage at Paskenta Reservoir, that the reservoir would be at a high operating level most of the time and would thus be conducive to recreation development.

Newville Reservoir would be operated on a Delta firming schedule. During average or wet years, there would be but minor releases from the reservoir; during critically dry years the entire storage of the reservoir could be released. Thus, there is a possibility that the reservoir could be full for a period of years, providing a constant pool for recreation use.

The combined long-term (1911-61) mean annual full natural flow into Paskenta-Newville Reservoir is about 210,000 acre-feet. Of this, about 200,000 is attributable to Thomes Creek. According to water supply data of September 29, 1960, about 30,000 acre-feet is presently being put to beneficial use. Thus, on the average, only 180,000 acre-feet per year can be considered as storable for new water development. As a practical matter, the 30,000 acre-feet might be stored during the initial reservoir filling period. However, this would require releases of this amount of water from some other reservoir in the system and would properly be assigned as a project cost.

One factor demanding considerable attention is the time required to fill the reservoir. The high storage-inflow ration at this site requires that special attention be given to the maximum reservoir capacity which should be considered. The largest capacity which is being considered at this time is one that would provide for annual releases equal to the long-term mean annual storable inflow minus evaporation losses. Storage-yield data indicates that the reservoir capacity at this point, which might be called the "hydrologic limit", is about 1,200,000 acre-feet. A cursory probability analyses has shown that about ten years would be required to fill a reservoir of this capacity, assuming local irrigation and fisheries enhancement releases were made during the filling period. The filling time would represent a cost in the econimic analysis of the project.

Conclusions

1. The Paskenta-Newville Reservoir Project appears to be a good early-stage addition to the State Water Resources Development System. The project would conserve and develop the flows of Thomes and North Fork Stony Creeks.

2. Reconnaissance-level studies indicate that the reservoir capacity for this project should be about 1,200,000 acre-feet.

3. The combined storage of 1,200,000 acre-feet in Paskenta-Newville Reservoir, when operated in coordination with the Central Valley Reservoir system, could develop a total annual yield of about 200,000 acre-feet. Portions of this new water supply would be available for comsumptive use in West Side Sacramento Valley service areas, for fisheries enchancement, and for export to the Sacramento-San Joaquin Delta.

4. The estimated capital cost of this project is about $30,000,000. If all costs are allocated to conservation, the average annual unit cost of the 200,000 acre-feet of yield is approximately $6.75 per acre-foot. Conclusion that this is a good early stage project results from comparisons with other proposed early stage developments.

West Side Conveyance System

The West Side Conveyance System would consist of a series of inter-connected reservoirs on the upper reaches of Cottonwood, Red Bank, and Elder Creeks in Shasta and Tehama Counties. It would extend from the Middle Fork of Cottonwood Creek south to Thomes Creek, a distance of 40 miles. The system would necessitate construction of 16 dams, ranging in heights to 285 feet; and open channel cuts through the intervening ridges, ranging in depths to 180 feet. Of the alternative alignments which have been studied, one generally following the 1,000-foot contour was selected as the most favorable. The component features and pertinent data of the system are shown on Plate 12.

Purpose

The primary purpose of the system, as the name implies, is for conveyance of water to the Glenn Reservoir Complex. The water sources would be imports from the Trinity, Mad, Van Duzen, and Klamath Rivers and surplus flows of Cottonwood, Red Bank and Elder Creeks. There also would be benefits associated with the West Side Conveyance System from flood control, fisheries enhancement, recreation, local irrigation and power.

Description of Area

The system would be located in the foothills of the Northern Coast Ranges, an area of moderate relief. The highest ridges in the immediate area rise to an elevation of 1,500 feet, while the elevation of the major stream channels is about 1,000 feet. The topography is characterized by sharp V-shaped canyons with numerous tributaries, all conspicuously marked by surface erosion.

The ground cover is range grasses, brush, and a few trees. The brush covered areas are typified by chamise, buckbrush, yerba santa, manzanita, and toyon. Blue oak and digger pine are found on the hilly land, while tree types along the stream courses, include cottonwood, buckeye, oak and willow. The climate is characterized by hot dry summers. Winters are usually moderate, with many clear, comfortable days between storms.

Alternative Conveyance Routes

It is presently envisioned that water developed on the Trinity, Mad, Van Duzen, and the Klamath Rivers would be routed to the Sacramento Valley through Helena Reservoir. There are two alternative diversion routes from Helena Reservoir to the Sacramento Valley. They are: (1) via a 12-mile gravity-flow tunnel to Clear Creek, thence through a series of power reservoirs on Clear Creek, a tributary to the Sacramento River; and (2) via 20-mile gravity-flow tunnel into Cottonwood Creek, thence through Selvester Reservoir and powerplant, through the West Side Conveyance System into the Glenn Reservoir Complex and into the Sacramento River.

Present studies indicate that the Clear Creek route is more favorable than the Cottonwood Creek route. However, no firm decision can be made until more detailed information becomes available. There are two factors which will have considerable bearing on this decision. One is the determination of the amount of reregulatory storage necessary to make the schedule of diversions from the Trinity River compatible with demands in the Central Valley; the other is the future unit value of hydroelectric power. The alternative routes are discussed in the next section of this chapter.

Water Supply

Surface runoff in this area generally follows the precipitation pattern, since contribution from snow melt is negligible. The average seasonal precipitation on the area above the West Side Conveyance System ranges from 25 inches in the lower elevations to 70 inches in the higher elevations. The average for the 693 square mile drainage area is about 40 inches.

There are no stream gaging stations along the route of the conveyance system. Therefore, water supply was based on area-precipitation relationships with recorded flows from nearby stations. The base stations which were used in determining these relationships are Cottonwood Creek near Cottonwood and Thomes Creek near Paskenta. The 20-year (1922-41) mean annual natural runoff of the area above the West Side Conveyance System is estimated to be 430,000 acre-feet. The storable inflow for this same period is about 330,000 acre-feet per year.

Operation

The West Side Conveyance System would remove flood flows from the upper reaches of Cottonwood, Redbank, and Elder Creeks. These flood flows, along with the imported water from the North Coastal area, would be conveyed to Glenn Reservoir for regulation. It would be necessary to maintain the reservoirs of the West Side Conveyance System at or near normal pool level in order to allow flow through the system. However, releases would be made to the various local streams for fisheries enhancement and local use. During a period of extreme drought the water stored in the reservoirs below cut level could be released for downstream use. The combined active storage in the system amounts to about 600,000 acre-feet. The open channels between Reservoirs of the West Side Conveyance

System would pass a base flow of 10,000 second-feet, plus sufficient capacity to carry the standard project flood peak outflow from the component reservoirs. The probable maximum flood was routed through the system to determine depth of cuts and freeboard allowances. The base inflow of 10,000 second-feet was selected as being representative of the magnitude of future imports from the Trinity and Klamath Rivers.

Benefits

Although detailed evaluations of benefits have not been made, the physical and operational characteristics of the West Side Conveyance System appear favorable for the development of fisheries enhancement, flood control, and recreation.

The system is located in the upper reaches of the drainage basins and could, in association with Trinity and Klamath River imports, provide flows for downstream release. These factors together with the availability of spawning gravels make the West Side Conveyance System a potentially good fisheries enhancement project.

As mentioned previously, flood flows would be removed from the upper basins of the tributary streams. Thus, the system would provide a large amount of flood control within these drainages. In addition, there would be a reduction of flood flows in the Sacramento River.

The West Side Conveyance System would be operated in such a manner that water levels in the reservoirs would fluctuate very little. This type of operation would be conducive to recreation development. The system is located in rolling hill country, and although some steep canyons are encountered, most of the terrain has the characteristics for economical development of recreation access and facilities. However, recreation development on the West Side Conveyance System would be inhibited by the presence of Shasta Lake, Whiskeytown, and Trinity Reservoirs to the north, and Glenn, Black Butte, and Oroville Reservoirs to the south.

Along with the development and conveyance of export water, the West Side Conveyance System could supply water to local agricultural service areas in the lower Cottonwood Creek Basin and in other minor drainages.

Studies for Plate 12

Although primary consideration was given to the West Side Conveyance System as part of the works for diverting Trinity and Klamath River flows to Glenn Reservoir, the system was also studied as an individual project of conservation works. In this plan, the system would conserve and divert to Glenn Reservoir surplus flows from the tributary streams. Plate 12 presents a summary of the costs and yield accomplishments of a plan including the West Side Conveyance System, Glenn Reservoir Complex, and imports from the Middle Fork Eel River.

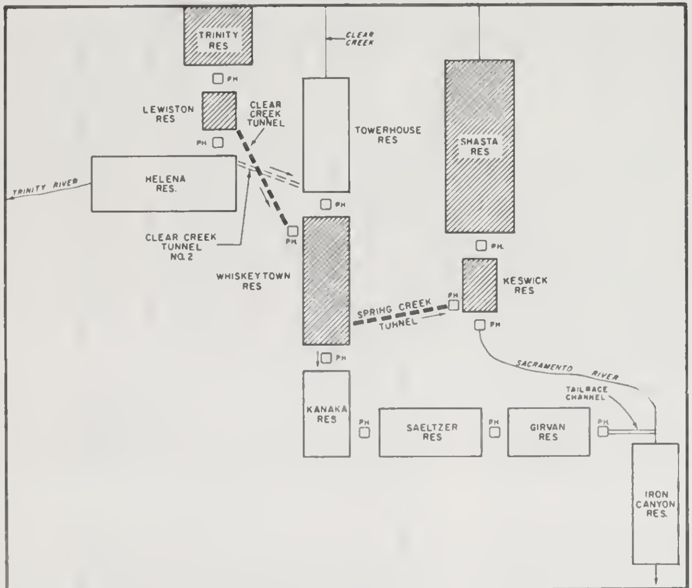
Pertinent conclusions which can be drawn from Plate 12 are: the West Side Conveyance System can develop a net new yield of about 320,000 acre-feet, when operated in conjunction with Glenn Reservoir with a capacity of about 8,000,000 acre-feet. The corresponding capital and annual unit costs of the yield are $130,000,000 and $20 per acre-foot respectively.

Related Studies

The West Side Conveyance System includes the proposed Fiddlers Reservoir on the Middle Fork of Cottonwood Creek. Fiddlers Reservoir was also studied under the Department's Upper Sacramento River Basin Investigation, which included the entire Cottonwood Creek Basin and the Thomes Creek Basin above Paskenta. Under the Upper Sacramento River Basin Investigation, numerous individual projects including Fiddlers, Dippingvat, and Rosewood Reservoirs have been investigated for purposes of local water supply, flood control, fisheries enhancement and recreation.

Alternative Conveyance Routes Trinity and Klamath River Developments

Studies to date have indicated that Helena Reservoir on the Trinity River would be the most favorable forebay for all Trinity and Klamath River diversions to the Sacramento River Basin. There are two basic routes for the necessary tunnel from Helena Reservoir to the Sacramento River Basin: either to Clear Creek or to Cottonwood Creek. The component features of these two routing plans are shown schematically on Figure 9. Pertinent physical data and estimated costs are presented on Plates 8 and 8A.

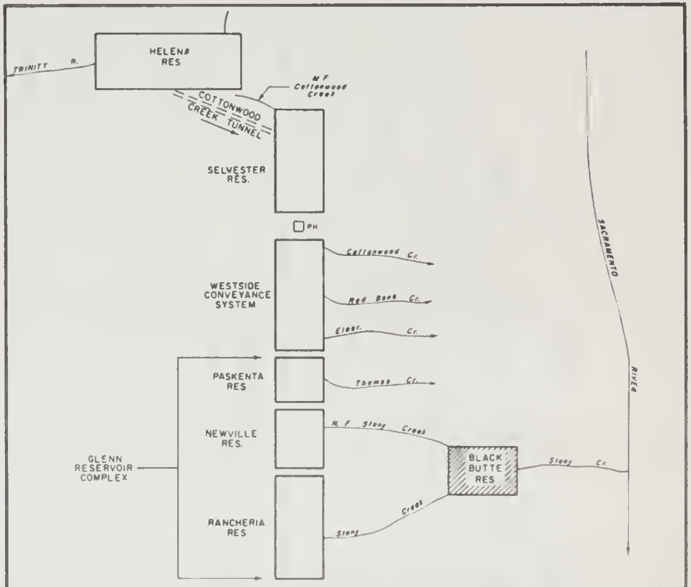


PLAN: Conveyance of water from the Trinity River Basin to the Sacramento River Basin via Clear Creek.

DATA: Annual diversion: 600,000 acre-feet to 8,000,000 acre-feet.
Tunnel intake elevation: 1500 to 1650

DISCUSSION: This export route is the most direct route to the Sacramento River from the Trinity River Basin. With the intake at elevation 1650 feet on the Trinity River, a tunnel approximately 11.5 miles in length would be required. This route offers the best power recovery route available, and has the advantage of utilizing the existing USBR's Whiskeytown Dam and Reservoir.

REFERENCES: Summary Plate 8



PLAN: Conveyance of water from the Trinity River Basin to the Sacramento River Basin via Westside Conveyance System and the Glenn Reservoir Complex.

DATA: Annual diversion: 600,000 acre-feet to 8,000,000 acre-feet.
Tunnel intake elevation: 1500

DISCUSSION: In this conveyance route, power would be generated only at the Selvester Powerplant. The Trinity River yield would be stored in the Glenn Reservoir Complex and released to the Sacramento River in coordination with the surplus flows at the Delta; thereby increasing the firm yield from the Trinity River. The Department's studies indicate that the Westside route would require a lower capital cost than the Clear Creek route. The net annual unit cost of the firm water supply in the Delta would be greater; however, due to less power revenue. The Westside Conveyance System would have added benefits of recreation, flood control, and fish enhancement and therefore should be studied in more detail as an alternate to the Clear Creek conveyance system.

REFERENCES: Summary Plate 8A and Plate 12

ALTERNATIVE EXPORT CONVEYANCE ROUTES
FOR
TRINITY RIVER AND KLAMATH RIVER DIVISIONS

FIGURE 9

CHAPTER V. TRINITY, MAD, VAN DUZEN RIVER BASINS

The water resources of the Trinity, Mad, and Van Duzen Rivers could be developed through staged construction of three physically integrated projects. The overall development, collectively termed the Trinity River Development, would be comprised of conservation features on the three North Coastal streams and conveyance facilities to and within the Sacramento River Basin. Only the alternative conservation works are discussed in this chapter. The conveyance systems are discussed in Chapter III.

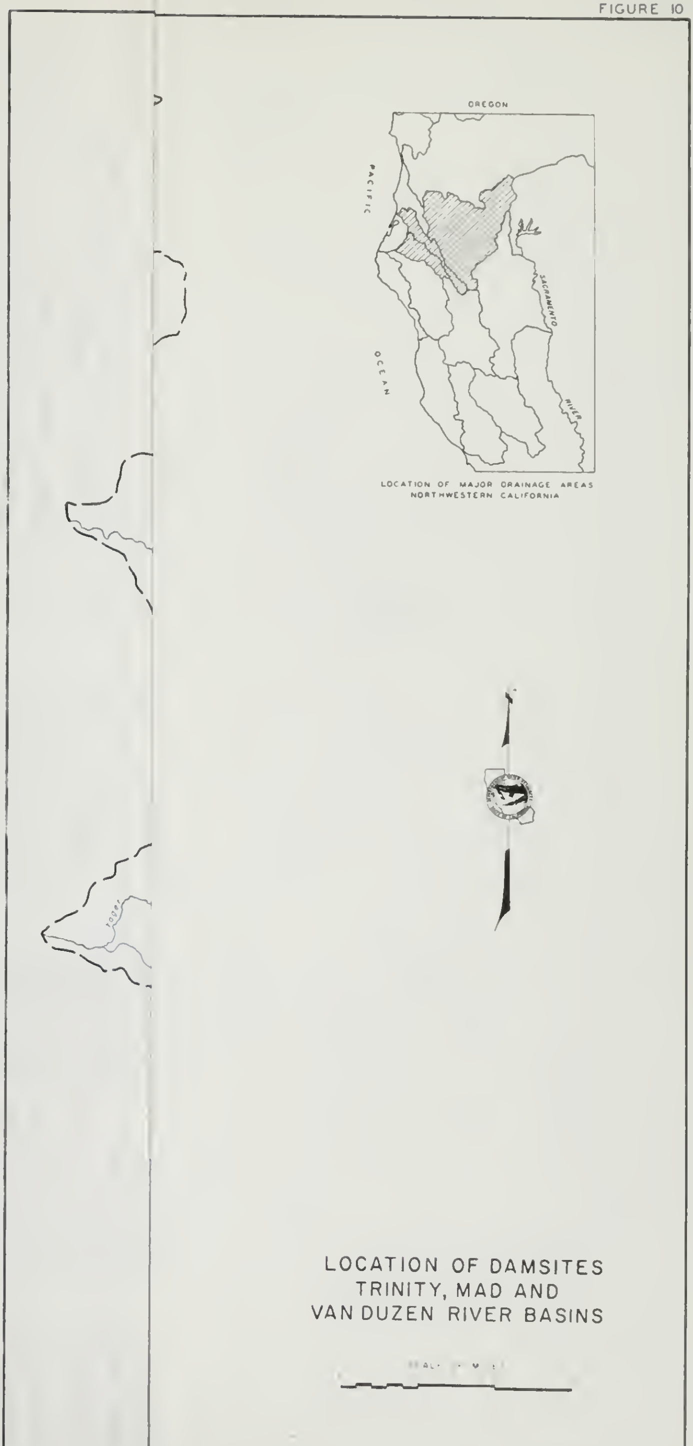
The drainage boundaries, stream system, and damsite locations are shown on Figure 10. Pertinent topographic and hydrographic data, referenced to damsites, are presented in Tables 4 and 5.

The three projects would develop about 1.8 million acre-feet of new annual yield, in approximately equal increments. The first stage of development would include a major dam on the main stem of the Trinity River located about 42 miles below Lewiston Dam. The second stage would include development of the water resources of the South Fork Trinity River, either with a reservoir on that stream or by a reservoir on the lower main Trinity River. The third stage would be to develop the Mad and Van Duzen Rivers and divert the new yield to and through the works of the first two stages.

The discussion of alternative plans for the Trinity River Development is preceeded by a short section on existing water development.

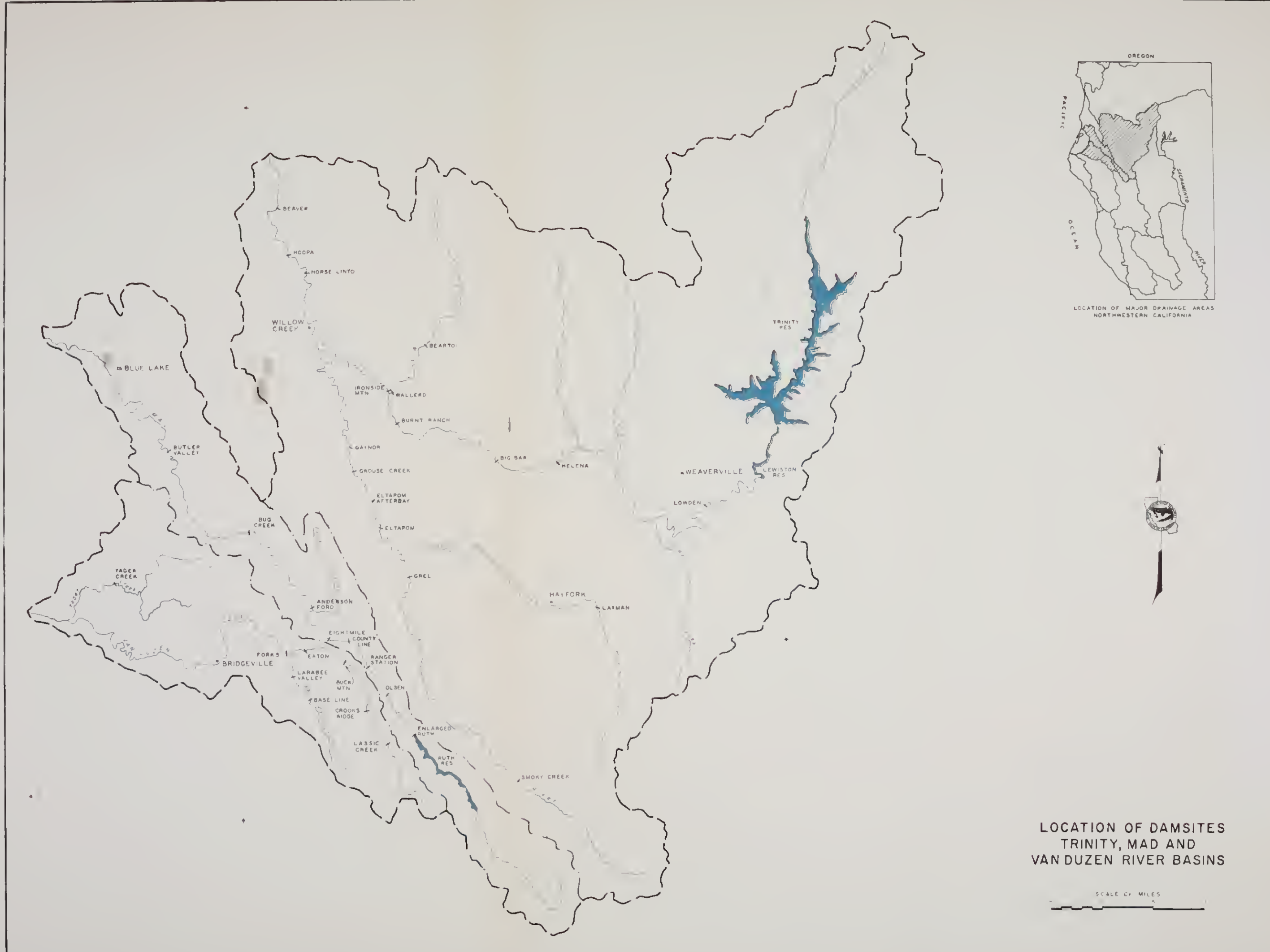
Existing Development

The only existing water development project in the Trinity River Basin is the Bureau of Reclamation's Trinity River Division of the Central Valley Project. This development which was completed in 1963, includes four dams, four powerplants, two tunnels, and a fish hatchery. Trinity Dam and Reservoir on the Trinity River, the major storage feature, has a gross storage capacity of 2,500,000 acre-feet at a normal pool elevation of 2,370 feet. Releases from Trinity Reservoir are utilized by the 100,000-kilowatt Trinity Powerplant. Water released from Trinity Powerplant is reregulated in Lewiston Reservoir, which has a gross storage capacity of 14,600 acre-feet at a normal pool elevation of 1,902 feet. Releases from Lewiston Reservoir are utilized



LOCATION OF DAMSITES
TRINITY, MAD AND
VAN DUZEN RIVER BASINS

DEPARTMENT OF WATER R



LOCATION OF DAMSITES
TRINITY, MAD AND
VAN DUZEN RIVER BASINS

TABLE 5
TRINITY BASINS

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Lowden	Trinity River	S. 28, T33N, R9W, MDB&M	808	1,350	1,685	Used for pump-lift to Lewiston Res.
Helena	Trinity River	S. 36, T34N, R12W, MDB&M	1,296	1,899	1,280	Best first stage development
Big Bar	Trinity River	S. 4, T4N, R8E, HB&M	1,353	1,958	1,165	Alternative to Helena
Burnt Ranch	Trinity River	S. 13, T5N, R 6E, HB&M	1,450	2,050	870	Pump-lift to Helena Res.
Ironside	Trinity River	S. 35, T6N, R6E, HB&M	1,705	2,476	660	Pump-lift to Burnt Ranch Res.
Horse Linto	Trinity River	S. 5, T7N, R5E, HB&M	2,734	3,846	325	Possible major storage feature on L. Trinity
Beaver	Trinity River	S. 2, T8N, R4E, HB&M	2,951	4,000	230	Alternative to Horse Linto
Beartooth	New River	Lat. 40° 55' Long. 125° 25'	180	303	1,210	Best site for New River development
Wallered	New River	S. 25, T6N, R6E, HB&M	233	360	900	Alternative to Beartooth
Layman	Hayfork Cr.	S. 15, T31N, R11W, MDB&M	91	85	2,490	For irrigation of Hayfork V. & fish enhance.
Smokey Cr.	S.F. Trinity	S. 5, T28N, R12W, MDB&M	132	180	2,485	Fish enhancement
Forest Glenn	S.F. Trinity	S. 13, T1S, R7E, HB&M	208	280	2,190	Used for exporting to the N.F. Eel R.
Grel	S.F. Trinity	S. 1, T2N, R6E, HB&M	338	450	1,360	Possible power dam
Eltapom	S.F. Trinity	S. 3, T3N, R6E, HB&M	767	927	1,210	Major storage feature on the S.F. Trinity
Grouse Creek	S.F. Trinity	S. 7, T4N, R6E, HB&M	867	1,032	850	Possible alternate to Eltapom
Gaynor	S.F. Trinity	S. 31, T5N, R6E, HB&M	875	1,046	775	Possible power feature
Hoopa	Trinity River	S. 25, T8N, R4E, HB&M	2,848	3,988	330	Lower level diversion, for import from Klamath

by the 350-kilowatt Lewiston Powerplant and also provide downstream releases for the important Trinity River fishery. A fish hatchery is located just below Lewiston Dam, for maintenance of the Trinity River fisheries. Most of the water developed by the project is diverted from Lewiston Reservoir through Clear Creek Tunnel (17.5 feet in diameter and 10.8 miles in length to the 134,000-kilowatt Clear Creek Powerplant which is just above Whiskeytown Reservoir. Whiskeytown Reservoir has a normal pool elevation of 1,210 feet and a gross storage capacity of 250,000 acre-feet. Releases are made to Clear Creek from Whiskeytown Reservoir for downstream uses and fish enhancement. Water is diverted from Whiskeytown Reservoir through Spring Creek Tunnel (18.5 feet in diameter and 2.9 miles in length) to the 150,000-kilowatt Spring Creek Powerplant, thence into Keswick Reservoir on the Sacramento River. Spring Creek Debris and Pollution Control Dam, which is a part of the Trinity River Project, is operated for pollution control of the upper Sacramento River. In summary, the Trinity River Division provides a downstream release of 120,000 acre-feet per year, an average annual diversion of 865,000 acre-feet into the Sacramento River Basin, and develops a dependable power capacity of 384,000 kilowatts.

The two existing water development projects in the Mad River Basin which are both owned and operated by the Humboldt Bay Municipal Water District include Ruth Dam and Reservoir and Sweasy Dam and Reservoir. Ruth Reservoir on the upper Mad River has a normal pool elevation of 2,654 feet and a gross storage capacity of 52,000 acre-feet. Firming releases from Ruth Reservoir provide a yield of 84,000 acre-feet per year. The water is pumped from the Mad River near Arcata by means of three Ranney collectors, for distribution to the Arcata-Eureka area.

There are no water development projects in the Van Duzen River Basin at the present time.

First Stage Trinity River Development

The first stage of additional Trinity River Development would be to conserve water on the main stem of the Trinity River, below Lewiston Dam. The project would include one large reservoir on the Trinity River and a diversion tunnel through the mountains to the Sacramento River Basin. Two damsites, Helena and Big Bar, were investigated as possibilities for impounding the required storage. Big Bar damsite is about 135 feet lower in streambed elevation than Helena. In all aspects in which the two sites were compared, Helena was considerably more favorable. These points of comparison included cost of gross storage, cost of active storage, cost of new water yield, and cost of transbasin diversion tunnel. For these reasons, it is presently assumed that the first stage project will include Helena Dam and Reservoir.

Helena Reservoir would back water up to the toe of Lewiston Dam, which acts as a control on the sizing of the project. The reservoir would have a gross capacity of 2,860,000 acre-feet and a water surface area of 15,800 acres at a normal pool elevation of 1,840 feet. The dam would be rockfill, about 585 feet high. Pertinent physical and cost data for Helena Dam and Reservoir is summarized on Plate No. 9.

Second Stage Trinity River Development

The alternative plans for the second stage of the Trinity River Development are more numerous, considerably more complex, and offer a greater planning latitude than plans for the first stage. Considerable additional study is required before the most favorable plan can be selected.

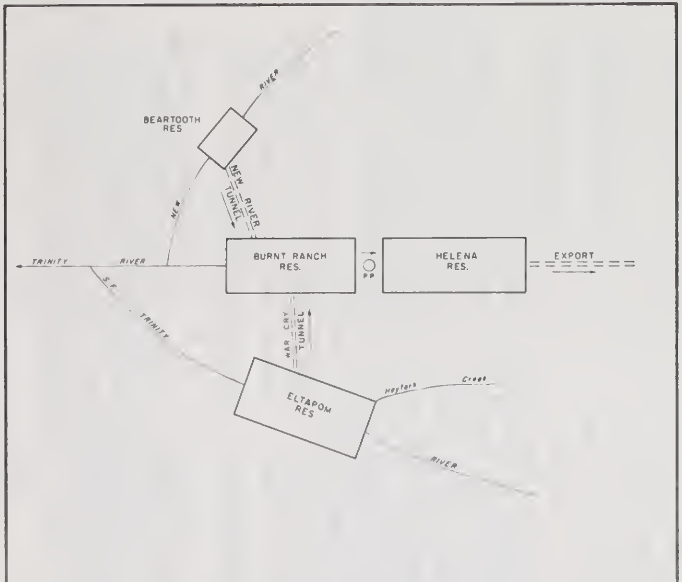
Most of the water supply for the second stage will be derived from the South Fork Trinity River. An additional increment could come from the New River. Both of these streams could be developed either by on-stream storage reservoirs with tunnel diversions to the main Trinity River, or by a large reservoir on the lower main stem, which in effect would develop the streams as main stem accretions below Helena Dam.

In this section, four alternative plans for the second stage project are presented. These plans are shown schematically in Figures 11 and 12. A brief discussion of each plan follows.

Gravity Plan

This project would include a large Eltapom Dam and Reservoir on the South Fork Trinity River and a gravity-flow tunnel to Helena Reservoir. This plan was presented in the Preview Report to Bulletin No. 136, published in September 1963. The project would not include any development of the New River.

The advantages of this plan are that the full yield potential of the South Fork at Eltapom damsite would be developed (about 600,000 acre-feet

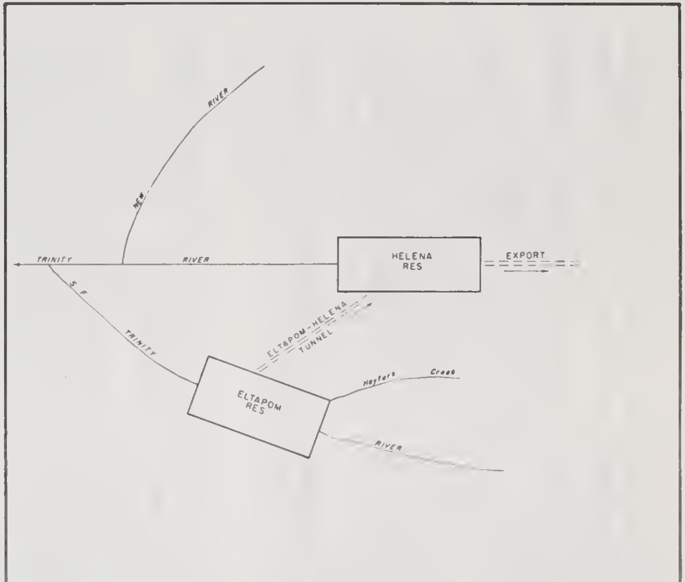


PLAN: Pump Plan, conservation of South Fork Trinity River with conveyance to the Trinity River and thence pumped into Helena Reservoir. Also includes New River plan for development.

DATA: Annual diversion: [illegible] acre-feet
Capital cost: [illegible]
Annual unit cost: [illegible] per acre-foot (in Helena Reservoir)

DISCUSSION: South Fork Trinity River is developed in a low Eltapom Reservoir, conveyed through the Eltapom-Burnt Ranch Tunnel to Burnt Ranch Reservoir on the Trinity River, and then pumped into Helena Reservoir for export to the Sacramento Valley. New River water is developed in Beartooth Reservoir, conveyed through the New River Tunnel to Burnt Ranch Reservoir and then pumped into Helena Reservoir. This plan requires the lowest unit annual cost for development of the South Fork Trinity River water, and utilizes a relatively low Eltapom Dam where geologic conditions seem to be unfavorable for a high dam. This plan has two drawbacks in that the South Fork is not developed to its full yield potential, and that the water developed requires pumping.

REFERENCES: Summary Plate 10B



PLAN: "Gravity Plan", conservation of South Fork Trinity River water with conveyance by gravity to the Trinity River for export to the Sacramento Valley.

DATA: Annual diversion: 600,000 acre-feet
Capital cost: $230,000,000
Annual unit cost: $18 per acre-foot (in Helena Reservoir)

DISCUSSION: South Fork Trinity River water is developed in a relatively high Eltapom Reservoir, and conveyed by gravity through the Eltapom-Helena Tunnel to Helena Reservoir for export to the Sacramento Valley. This plan develops the full yield potential of the Eltapom damsite. This yield is conveyed by gravity to the Trinity River, and provides a gravity conveyance system for future Mad and Van Duzen Rivers export. However, the plan has a higher annual unit cost for development of the South Fork Trinity River water and requires a relatively high Eltapom Dam where geologic conditions seem to be unfavorable for a high dam.

REFERENCES: Summary Plate 10A

ALTERNATIVE CONSERVATION FACILITIES
FOR SECOND STAGE
TRINITY RIVER DEVELOPMENT

FIGURE 11

annually) and a gravity-flow system would be provided for third-stage diversions from the Mad and Van Duzen Rivers.

The disadvantage of this plan is related to the height of dam which would be required at Eltapom damsite. A high dam, and a large inactive storage, is needed because of the relative elevations of Eltapom, and Helena sites and the diversion tunnels to and from Helena Reservoir. Geologic investigation has revealed two faults at the Eltapom damsite. These are reflected in an unfavorably high cost estimate, if indeed a high structure could ever be built on the site.

A summary of data on the gravity plan is presented on Plate 10A.

Pump Plan

This plan was formulated subsequent to the aforementioned "gravity plan" as an alternative to a high dam at the Eltapom site. This is the project presented in Bulletin No. 136.

The "pump plan" of second stage development would include three dams, two tunnels, and a pumping plant. A summary of data on the plan and its features is presented in Plate 10B. The following paragraphs briefly describe each feature.

Under this plan, Eltapom Reservoir would be formed by construction of a 330-foot high earthfill dam on the South Fork Trinity River immediately downstream of Eltapom Creek. At a normal pool elevation of 1,522 feet, the reservoir would have a gross capacity of 730,000 acre-feet and a water surface area of 4,650 acres. The reservoir would conserve the surplus flows of the South Fork and reregulate third stage diversions from the Mad-Van Duzen Project. Approximately 400,000 acre-feet of water would be diverted annually from the reservoir through War Cry Tunnel to Burnt Ranch Reservoir. Releases also would be made for fisheries and downstream needs.

War Cry Tunnel would extend from Eltapom Reservoir to Burnt Ranch Reservoir. The tunnel would be 15 feet in diameter and 10.2 miles long. It would be sized to include capacity for later-staged water from the Mad-Van Duzen Project.

The diversion of about 120,000 acre-feet of water from the New River to Burnt Ranch Reservoir would be accomplished by Beartooth Reservoir and New River Tunnel. Beartooth Reservoir would be formed by a 285-foot high earthfill dam on the New River about 1 mile upstream of Panther Creek. The reservoir would have a gross capacity of 36,000 acre-feet and a water surface area of 410 acres at a normal pool elevation of 1,475 feet. New River Tunnel would be 12 feet in diameter and 8.3 miles long.

Burnt Ranch Reservoir would be formed by construction of a 600-foot high rockfill dam on the Trinity River about 3 miles upstream of the confluence with the New River. The reservoir would have a gross capacity of 980,000 acre-feet and a water surface area of 5,300 acres at a normal pool elevation of 1,437 feet. The reservoir would develop about 80,000 acre-feet of new yield from the incremental runoff between Helena Dam and Burnt Ranch Dam. It would also reregulate diversions from the South Fork Trinity River and the New River and would serve as a forebay for the Helena Pumping Plant.

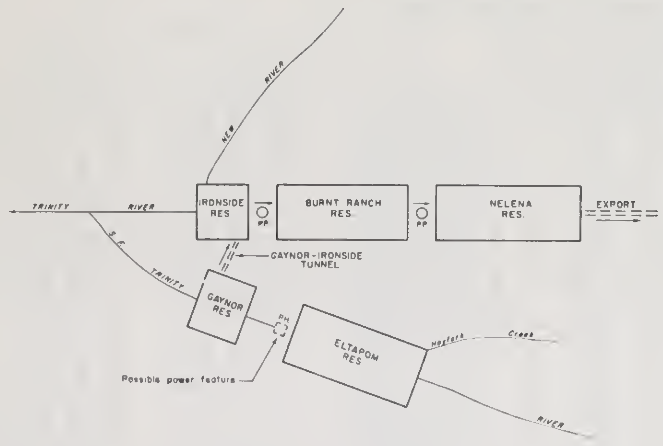
Gaynor Plan

Under this plan water would be diverted from Gaynor Reservoir on the lower South Fork Trinity River to Ironside Reservoir on the main stem Trinity. The developed water would be pumped from Ironside into Burnt Ranch Reservoir, then into Helena Reservoir. This plan has the advantage of a short tunnel from the South Fork to the Trinity River. However, the plan is apparently less favorable than either the preceding pump plan or the Horse Linto Plan.

Horse Linto Plan

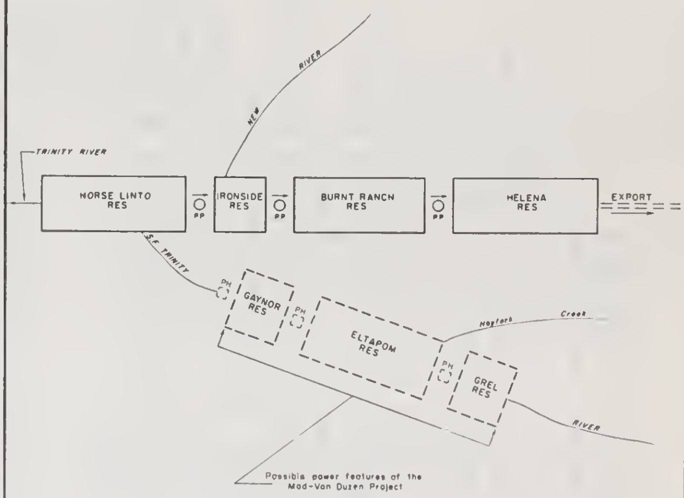
The fourth basic alternative plan for second-stage Trinity River Development would be to construct a large conservation reservoir on the lower main Trinity River, below the South Fork's confluence, and pump the developed yield up through two small reservoirs and into Helena Reservoir. A dam at the Horse Linto site, located just above Hoopa Valley, could impound the required large reservoir. The two smaller reservoirs would be Ironside Mountain and Burnt Ranch. Three pumping plants would be required in this plan.

Only cursory analysis has been made of this plan to date. Its apparent advantages are that the Horse Linto site looks favorable from a cost standpoint and the plan would take advantage of projected lower energy costs for pumping. One possible disadvantage, which could turn out to be irrevelant, is that the plan would not be compatible with a later-staged big Humboldt Dam and Reservoir.



PLAN: Conservation of South Fork Trinity River with conveyance to the Trinity River and then pumped into Relena Reservoir for export to the Sacramento Valley.

DISCUSSION: South Fork Trinity River water is developed in Eltapom and Gaynor Reservoirs, conveyed to Ironside Mountain Reservoir on the Trinity River by the Gaynor-Ironside Mountain Tunnel, and then pumped into Burnt Ranch Reservoir and then into Relena Reservoir for export to the Sacramento Valley. This plan has the advantage of a short tunnel from the South Fork of the Trinity to the Trinity River, and also integrates into the Klamath River development plan very well in that it includes Ironside Mountain Dam and Reservoir, Burnt Ranch Dam, Reservoir, and Pumping Plant, and Nelena Pumping Plant. The main disadvantage is that it develops the yield at a low level and requires pumping from Ironside Mountain Reservoir to Relena Reservoir.



PLAN: Conservation of South Fork Trinity River in a reservoir on the main stem of the Trinity River below the confluence of the South Fork of the Trinity River and then pumped into Helena Reservoir.

DISCUSSION: South Fork Trinity and main stem Trinity River water is developed in Horse Linto Reservoir, and then pumped into Ironside Mountain Reservoir, then into Burnt Ranch Reservoir, and finally into Relena Reservoir for export to the Sacramento Valley. This plan develops the full potential yield of the main stem of the Trinity and the South Fork of the Trinity Rivers, and in so doing does not flood out Hoopa Valley. It has the disadvantage of pumping the yield from a low elevation, and that the plan does not integrate into a possible "Big Humboldt" development of the Klamath River.

Power development shown on the South Fork of the Trinity River could be constructed when Mad and Van Duzen River water is diverted to the basin.

ALTERNATIVE CONSERVATION FACILITIES FOR SECOND STAGE TRINITY RIVER DEVELOPMENT

FIGURE 12

Third Stage Trinity River Development

The third stage of the Trinity River Development would be to develop water on the Mad and Van Duzen Rivers and convey it to and through the works of the two previous stages. The basic features and functional aspects of the plan would be as follows: either one or two reservoirs would be constructed on the Van Duzen River and the yield diverted by tunnel or conduit to the Mad River Basin; a new reservoir would be constructed on the Mad River, to supplement Ruth Reservoir and to serve as a forebay for diversion to the South Fork Trinity River Basin.

A number of alternative plans for developing the Mad and Van Duzen Rivers have been analyzed. Several of the plans have been studied in considerable detail; others have received only a reconnaissance appraisal of their functional and operational aspects. Six possible plans are presented in this section. Four of these are shown schematically in Figure 13. A brief discussion of each plan follows.

Plan Shown in Bulletin No. 136

The plan shown in Bulletin No. 136 would include two dams on the Van Duzen River, two new dams and the enlargement of Ruth Dam and Reservoir on the Mad River, two tunnels, and one powerplant. About 600,000 acre-feet of firm yield would be diverted to the South Fork Trinity River for subsequent conveyance to the Sacramento River Basin. Pertinent data for the plan is summarized on Plate No. 11. Project features are described briefly in the following paragraphs.

Larabee Valley Dam and Reservoir. Larabee Valley Reservoir would be formed by the construction of a 452-foot high earthfill dam on the South Fork Van Duzen River about 1.5 miles upstream from the confluence with the main stem of the Van Duzen River. The reservoir would have a gross capacity of 568,000 acre-feet and a water surface of 4,050 acres at a normal pool elevation of 2,686 feet. Approximately 130,000 acre-feet per year would be diverted from Larabee Valley Reservoir through a 2.5 mile-long pipeline to Eaton Reservoir.

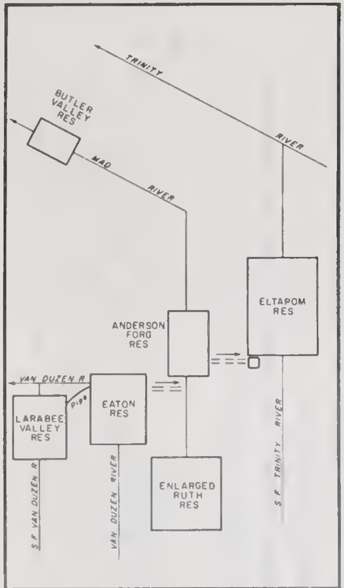
Eaton Dam and Reservoir. Eaton Reservoir would be formed by the construction of a 381-foot high earthfill dam on the Van Duzen River approximately 1.5 miles upstream of the confluence with the South Fork Van Duzen.

TABLE 6

MAD AND VAN DUZEN RIVER BASINS

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Ruth	Mad River	S. 19, T1S, R7E, HB&M	121	180	2,540	Existing enlarged Ruth would be key feature
Olsen	Mad River	S. 34, T1N, R6E, HB&M	130	195	2,470	Possible alternate to Anderson Ford
Lamb Creek	Mad River	S. 21, T1N, R6E, HB&M	140	212	2,414	Possible alternate to Anderson Ford
Ranger Station	Mad River	S. 17, T1N, R6E, HB&M	144	218	2,397	Main storage feature in Bul.#3, poor geology
County Line	Mad River	S. 6, T1N, R6E, HB&M	155	237	2,335	Possible alternate to Anderson Ford
Eight Mile	Mad River	S. 34, T2N, R5E, HB&M	158	242	2,280	Possible alternate to Anderson Ford
Anderson Ford	Mad River	S. 16, T2N, R5E, HB&M	211	331	2,077	Primarily a diversion & head developer
Showers Cr.	Mad River	S. 26, T3N, R4E, HB&M	235	401	1,850	Possible diversion feature
Taylor Ridge	Mad River	S. 16, T3N, R4E, HB&M	252	450	1,470	Possible diversion feature
Bugs Creek	Mad River	S. 9, T3N, R4E, HB&M	265	487	1,380	Possible diversion feature
Butler Valley	Mad River	S. 6, T4N, R3E, HB&M	352	740	307	Replaces existing Ruth; provides add'l local water
Blue Lake	Mad River	S. 8, T5N, R2E, HB&M	397	871	110	Possible power feature
Blue L. After Bay	Mad River	S. 6, T5N, R2E, HB&M	400	879	100	Possible power feature
Essex Diver.	Mad River	S. 15, T6N, R1E, HB&M	485	1,000	10	Possible diversion feature
Lasic	Van Duzen R.	S. 22, T1S, R6E, HB&M	39	111	2,700	Possible alternate to Eaton
Crooks Ridge	Van Duzen R.	S. 5, T1S, R 6E, HB&M	51	142	2,600	Possible alternate to Eaton
Buck Mtn.	Van Duzen R.	S. 13, T1N, R5E, HB&M	68	185	2,440	Possible alternate to Eaton
Eaton	Van Duzen R.	S. 5, T1N, R5E, HB&M	82	218	2,320	Principal storage feature on Van Duzen R.
Forks	Van Duzen R.	S. 12, T1N, R4E, HB&M	146	392	1,900	Possible diversion feature, to Mad River
Alton	Van Duzen R.	S. 24, T2N, R1W, HB&M	426	770	50	Off-stream storage for development of Lower Eel River
Base Line	So. Fk.	S. 33, T1N, R5E, HB&M	36	99	2,515	Fish enhancement & alternative to Larabee Valley
Larabee V.	So. Fk.	S. 19, T1N, R5E, HB&M	55	150	2,320	Possible export feature on S.F. Van Duzen River
Yager	Yager Creek	S. 6, T2N, R2E, HB&M	127	264	430	Possible alternate or addition to Buttler V.

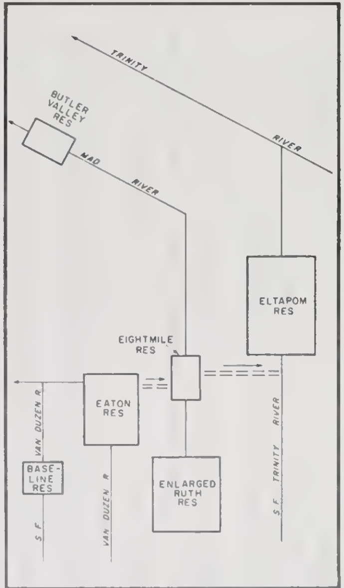


PLAN SHOWN IN BULLETIN NO. 136

This development could yield up to 600,000 acre-feet per year on a power schedule. Based on power values used during the studies, this water would cost only about $3.00 per acre-foot delivered to Eltapom Reservoir. However, if the recently revised power values are used, the unit cost of the water would be increased by about 2½ dollars per acre-foot.

The capital cost of the project sized to deliver 600,000 acre-feet annually into Eltapom Reservoir would be under $200,000,000 based on very preliminary estimates. From Plate 11, Chart M, it can be seen that water from Larabee Valley is by far the most expensive.

Butler Valley Reservoir would be used to supply water to Humboldt Bay instead of Ruth Reservoir. This is true in all four plans shown.

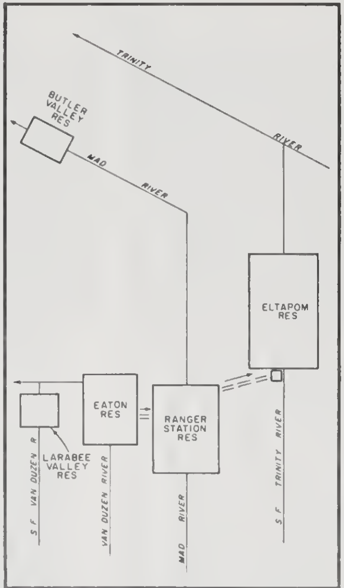


SMALLER SCALE ALTERNATIVE TO BULLETIN 136 PLAN

In this plan, Base Line Reservoir would be for fish enhancement and local use only. This would allow all yield from Eaton Reservoir to be exported.

Eight Mile Reservoir would take the place of Anderson Ford Reservoir. It would cost less, but the yield would also be less.

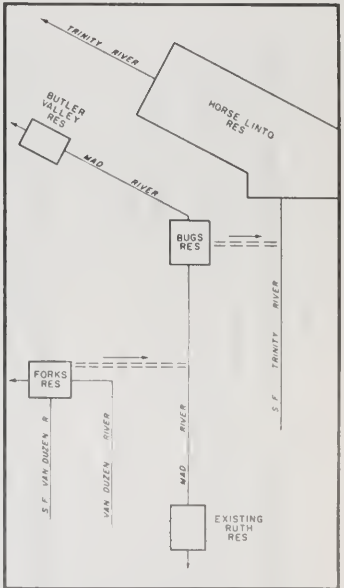
Maximum yield from this plan would be about 350,000 acre-feet.



BULLETIN NO. 3 PLAN

This plan was formulated in 1954 for Bulletin No. 3. Since that time Ruth Reservoir has been constructed for Humboldt Bay M.U.D. and Ranger Station damsite has been found unsatisfactory due to a large slide near the axis. No further studies were made on this plan, but it served as a basic concept to follow in formulating other plans.

Larabee Valley Dam and Reservoir would be constructed on the S.F. Van Duzen River for local use.



OUT-OF-BASIN STORAGE PLAN

This plan is based on the assumption that hydro-electric power is not feasible and that Horse Linto Reservoir would be built instead of Eltapom.

Under this assumption storage in Horse Linto would be used to develop the water from the Mad and Van Duzen Rivers since one large reservoir may provide cheaper storage than many small ones.

Forks, Bugs, and existing Ruth Reservoirs would provide limited storage for smoothing out highly erratic winter flows to fit tunnel capacities. During late spring these reservoirs would be allowed to fill so as to provide for fish enhancement and local needs.

Under this plan the yield in Horse Linto Reservoir resulting from the Mad-Van Duzen diversion could be in excess of 700,000 acre-feet annually.

ALTERNATIVE PLANS FOR DEVELOPMENT
OF THE
MAD AND VAN DUZEN RIVERS

FIGURE 13

The reservoir would have a gross capacity of 635,000 acre-feet and a water surface area of 4,050 acres at a normal pool elevation of 2,676 feet. Approximately 200,000 acre-feet of new water would be developed by Eaton Reservoir. This water, together with the diversion from Larabee Valley Reservoir, would be diverted via an 0.8-mile long Mad River Tunnel to Anderson Ford Reservoir on the Mad River.

Anderson Ford Dam and Reservoir. Anderson Ford Reservoir would be formed by the construction of a 372-foot high earthfill dam on the Mad River immediately downstream of Pilot Creek. The reservoir would have a gross capacity of 160,000 acre-feet and a water surface area of 1,400 acres at a normal pool elevation of 2,415 feet. Approximately 125,000 acre-feet of new water would be developed by Anderson Ford Reservoir. Approximately 600,000 acre-feet of new yield developed from the Mad and Van Duzen Rivers would be diverted from Anderson Ford Reservoir via South Fork Tunnel to the South Fork Trinity River.

South Fork Tunnel and Powerplant. Water diverted from Anderson Ford Reservoir would flow through a 4.7-mile long South Fork Tunnel to the South Fork Powerplant. The estimated capital cost of the 15-foot diameter tunnel is $28 million. The South Fork Powerplant, located on the edge of Eltapom Reservoir, would develop about 720 feet of power head.

Enlarged Ruth Reservoir. An enlarged Ruth Reservoir would be formed by the construction of a 277-foot high earthfill dam on the Mad River. The existing dam would be utilized as part of the enlarged embankment. The present capacity of 52,300 acre-feet would be increased to a gross capacity of 480,000 acre-feet. The new reservoir would have a water surface area of 5,420 acres at a normal pool elevation of 2,787 feet. The existing recreation development would be relocated to the edge of the enlarged lake. Approximately 145,000 acre-feet of new yield could be developed by the enlarged lake. Project commitments of the Humboldt Bay Municipal Water District would be met from replacement storage constructed on the Mad River at the Butler Valley site.

Butler Valley Dam and Reservoir. Butler Valley Reservoir would be formed by the construction of a 225-foot high earthfill dam on the Mad River about 6 miles upstream of Sweasy Dam. More recent area-elevation-capacity data than that utilized for page 90 of Bulletin No. 136 and for

Plate No. 11 indicate that the reservoir would have a gross capacity of 94,000 acre-feet and a water surface area of 1,460 acres at a normal pool elevation of 460 feet. Water developed in the reservoir would be released to provide a supply to the Eureka-Arcata area. Flows would also be provided for fisheries.

Bulletin No. 3 Plan

This plan was formulated in 1954 for inclusion in Bulletin No. 3, The California Water Plan, published in 1957. The system included Eaton Dam and Reservoir, Mad Tunnel, Ranger Station Dam and Reservoir, Sulphur Glade Tunnel, and Sulphur Glade Powerplant. In the plan, Ranger Station Reservoir would function as the storage and diversion reservoir on the Mad River and Eaton Reservoir would be the storage reservoir on the Van Duzen River. Approximately 400,000 acre-feet per year of firm yield would be developed by these works.

Out-of-Basin Storage Plan

The objective of this plan would be to divert the maximum amount of water from the Mad and Van Duzen Rivers to the South Fork Trinity River. It would be feasible only if a large reservoir such as Horse Linto were constructed on the Trinity River. Under such a plan Forks Reservoir at the junction of the South Fork and main stem of the Van Duzen River and Bug Creek Reservoir on the Mad River would function primarily as diversion features. This plan has not received detailed analysis. It appears, however, that up to 750,000 acre-feet could be diverted annually with this system.

Smaller Scale Alternative to Bulletin No. 136 Plan

Two of the reservoirs in the Bulletin No. 136 plan, Anderson Ford and Larabee Valley, are relatively costly for the amount of water developed. An alternative would consist of a plan of similar functional characteristics but on a smaller scale. Under this plan, Eight Mile Dam and Reservoir would be substituted for Anderson Ford and Baseline Dam and Reservoir would be substituted for Larabee Valley. This plan has not been analyzed in detail, but it appears 350,000 of annual yield could be developed.

Eight Mile Dam and Reservoir would be located on the Mad River approximately 2.5 miles downstream from the Humboldt-Trinity County Line.

In comparison to Anderson Ford damsite, Eight Mile damsite has three advantages: (1) the streambed elevation is approximately 200 feet higher, thus requiring a lower dam to provide water at equal elevation; (2) the construction materials are closer to Eight Mile damsite than Anderson Ford damsite (most of the fill material for these dams would come from the Van Duzen River above the town of Dinsmores); and (3) the unit cost of water from the Eight Mile system appears to be lower than that from the Anderson Ford system. Eight Mile Reservoir would have the major disadvantage of not developing the principal tributary of the Mad River, Pilot Creek, and therefore would provide less yield than Anderson Ford Reservoir.

Baseline Dam and Reservoir would be located on the South Fork Van Duzen River approximately one-half mile north of the Humboldt Baseline. This reservoir would not develop water for export out of the basin, but would be for fish maintenance and possibly enhancement flows in the South Fork and main stem of the Van Duzen River. Baseline Dam and Reservoir would eliminate the necessity for fish releases out of Eaton Reservoir, thereby increasing the yield of Eaton Reservoir. This project has definite possibilities and should be investigated further.

Alternatives to Bulletin No. 3 System

In an office report of March 1958 entitled "Office Report on Preliminary Investigation of Mad River", two systems were discussed that were alternatives to the Bulletin No. 3 system.

The first alternative consisted of a dam at the Ruth site, which would be the main storage feature; a dam at the Olsen site about 4.5 miles downstream from the Ruth site, for diversion of water from the Mad River to the South Fork Trinity River; and a diversion dam at the Crooks Ridge site on the Van Duzen River about 10 miles upstream from Dinsmores for diverting flow from the Van Duzen River to the Mad River. Releases from Ruth Reservoir would flow from the Mad River to Olsen Reservoir, which would also receive releases from CrooksRidge Reservoir through a 2-mile tunnel. The entire yield developed by the three reservoirs, about 220,000 acre-feet per season, would flow from Olsen Reservoir through a 3.3-mile tunnel to a powerplant on the South Fork Trinity River, which would develop 850 feet of head.

This alternative differs from the Bulletin No. 3 Plan in the inclusion of Ruth Dam and Reservoir on the Mad River in lieu of Ranger Station, and the substitution of smaller reservoirs at other sites on both the Mad and Van Duzen Rivers. It would also develop 220,000 acre-feet of yield annually compared to 400,000 acre-feet developed in the Bulletin No. 3 plan.

The second alternative would include the same dam and reservoir at the Ruth site contemplated in the first alternative, operated in conjunction with County Line Dam and Reservoir, located on the Mad River about 0.5 mile downstream from the Humboldt-Trinity County Line, and the Buck Mountain Dam and Reservoir on the Van Duzen River, located about 4 miles upstream from the community of Dinsmores. Releases from Ruth Reservoir would flow down the Mad River to County Line Reservoir, which would also receive releases from Buck Mountain Reservoir through a 0.5-mile tunnel at the same location as the tunnel between Eaton and Ranger Station Reservoirs in the Bulletin No. 3 system. These three reservoirs, with an aggregate active storage capacity of 433,000 acre-feet, would be operated coordinately to develop a firm yield of about 280,000 acre-feet per season for export through a 5-mile tunnel to the South Fork Trinity River. A substantial amount of power would be generated in the drop to the South Fork Trinity River.

This alternative differs from the Bulletin No. 3 Plan in the inclusion of Ruth Dam and Reservoir, and County Line Dam and Reservoir on the Mad River in lieu of Ranger Station Dam and Reservoir, and the smaller Buck Mountain Dam and Reservoir on the Van Duzen River instead of Eaton Dam and Reservoir. It would develop 280,000 acre-feet of yield a year compared to the 400,000 acre-feet developed in the Bulletin No. 3 Plan.

CHAPTER VI. LOWER EEL RIVER BASIN

In this presentation, the Lower Eel River is considered to consist of the main Eel River below its junction with the Middle Fork Eel near Dos Rios. The drainage basin and damsite locations are shown on Figure 14.

Basic planning criteria relative to the studies for the development of the water resources of this stream were as follows:

1. The primary purpose of development would be to divert surplus water from the Lower Eel River to the Sacramento-San Joaquin Delta for export to areas of deficiency.
2. No dam would be constructed below the confluence of South Fork Eel River near Weott, since this would result in the inundation of redwood groves which have aesthetic values greater than any water supply that could be developed from this stream.
3. The initial development on the Upper Eel River would occur at least 20 years prior to this development and would include English Ridge Dam and Reservoir at normal pool elevation of 1,695 feet and Dos Rios Dam and Reservoir at normal pool elevation of 1,325 feet.

Planning studies have shown that there is not much flexibility or latitude in formulating alternative plans for developing the Lower Eel River. The functional aspects of development dictate that the water be developed in on-stream reservoirs and that it be pumped "back up hill" through the reservoirs of the previously constructed Upper Eel River Development. The plan that has been formulated includes two large reservoirs on the Lower Eel River, Bell Springs, and Sequoia. Basic features of the plan are discussed in this chapter. Pertinent physical data and estimated costs are shown on Plate No. 19.

Plan of Development

Bell Springs Reservoir would be formed by the construction of a 490-foot high dam near the Bell Springs railroad siding in northern Mendocino County. The reservoir would have a gross storage capacity of 1.35 million acre-feet and a water surface area of 8,200 acres at a normal

LOCATION OF DAMSITES
LOWER EEL RIVER BASIN

TABLE 7

LOWER EEL RIVER BASIN

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Woodman	Eel River	S. 13&14, T22N R14W, MDB&M	1,495	2,057	820	Alternate to a large Bell Spring Res.
Bell Springs	Eel River	S. 30, T24N, R14W, MDB&M	1,578	2,152	650	Used for conveyance and storage
Willow Creek	Eel River	S. 26, T5S, R6E, HB&M	1,927	2,648	520	Alternate to Bell Springs
Island Mtn.	Eel River	S. 10, T5S, R6E, HB&M	1,953	2,678	405	Used with Woodman as alternate to Bell Spring
Sequoia	Eel River	S. 6 T2S, R4E, HB&M	2,241	3,166	140	Principal storage feature of L. Eel R.
Sequoia Afterbay	Eel River	S. 26, T1S, R2E, HB&M	2,270	3,216	105	Possible power feature
Branscomb	S.F. Eel R.	S. 4, T21N, R16W, MDB&M	42	106	1,405	Local project
Streeter	Tenmile Cr.	S. 21, T22N, R15W	47	---	1,445	Local project

pool elevation of 1,130 feet. The inactive storage in the reservoir would be 300,000 acre-feet at water surface elevation 925 feet, which is the approximate streambed elevation of the Middle Fork Eel River at Dos Rios damsite. The estimated capital cost of Bell Springs Dam and Reservoir, exclusive of railroad relocation costs, is $101 million.

Sequoia Reservoir would be formed by the construction of a 612-foot high dam on the Eel River, about 10 miles upstream of the confluence with the South Fork. The reservoir would have a gross capacity of 5.4 million acre-feet, a water surface area of 24,000 acres, and a normal pool elevation of 740 feet. The inactive storage in the reservoir would be 3.4 million acre-feet at water surface elevation 650 feet, which is the approximate streambed elevation of the Eel River at Bell Springs damsite. The estimated capital cost of the Sequoia Dam and Reservoir, exclusive of railroad relocation costs, is $175 million. It may be advisable to provide about 1 million acre-feet of additional storage capacity in Sequoia Reservoir specifically for flood control, in which case the normal pool elevation would be 780 feet. This provision would increase the capital cost of Sequoia Dam and Reservoir by about $21 million. The flood control benefits attributable to the additional storage capacity have not yet been determined however.

Approximately 600,000 acre-feet of water would be pumped annually from Sequoia Reservoir into Bell Springs Reservoir. The Sequoia-Bell Springs Pumping Plant would be located at the downstream toe of Bell Springs Dam. It would have an installed capacity of 62,000 kilowatts and would be capable of pumping the exportable water supply into Bell Springs Reservoir when operating during "offpeak" hours only. The plant would have an average annual energy requirement of 268 million kilowatt hours.

The firm annual yield from Bell Springs Reservoir would be approximately 400,000 acre-feet. The total water supply of 1 million acre-feet from the two reservoirs would be pumped from Bell Springs Reservoir into Dos Rios Reservoir. The Bell Springs-Dos Rios Pumping Plant would have an installed capacity of 90,000 kilowatts and would also operate during "offpeak" hours. It would have an average annual energy requirement of 392 million kilowatt hours.

The water supply would be conveyed from Dos Rios Reservoir to the Sacramento River Basin either by way of Clear Lake and Lake Berryessa or via Glenn Reservoir. The recommended route would probably be the same as that selected for the export facilities of the earlier constructed Upper Eel River Development. The current studies indicate that it would not be economical to oversize the conveyance system constructed with the initial Eel River development, to that capacity required for total development.

The cost of the reservoirs and conveyance facilities required to deliver firm quantities of water from the Lower Eel into either Dos Rios or English Ridge Reservoir is indicated on Plate No. 19. The cost of a Dos Rios-Grindstone Creek Tunnel is given in Chapter II, Table 2. The cost of the conveyance and power recovery facilities which would be utilized if the water supply is to be delivered from English Ridge Reservoir into the Sacramento River Basin via Clear Lake and Monticello Reservoir is given on Plate No. 6A.

Fisheries Preservation

Water would be released from Sequoia Reservoir for fisheries preservation. A fish hatchery would be located near the downstream toe of the dam. The amount of water required for operation of the hatchery and for stream releases has been estimated by the Department of Fish and Game as follows:

October 1 - April 30	--	650 cfs
May 1 - June 30	--	325 cfs
July 1 - September 30	--	120 cfs

These quantities total 334,000 acre-feet per year. A possible alternative to this plan would be to locate the fish hatchery at the junction of the South Fork and main Eel River. Under the alternative plan, releases would be made from Sequoia Reservoir to maintain the hatchery, and firm up the higher flows required for natural spawning below the hatchery. These flows could be largely supplied by the natural runoff of the South Fork Eel River. Releases from Sequoia Reservoir under this type of operation would average about 200,000 acre-feet per year.

Railroad Relocation

Construction of the proposed Sequoia and Bell Springs Reservoirs on the Lower Eel River would necessitate the relocation of approximately 100 miles of the Northwestern Pacific Railroad. This important transportation facility, which links the North Coastal area with the San Francisco Bay area, would probably be relocated from within the Eel River canyon to an alignment near the old Mail Ridge Road in Humboldt and Mendocino Counties. Preliminary estimates indicate that this relocation would cost on the order of $130 million. The cost of the railroad relocation is a primary reason why development of the Lower Eel River is currently not considered for early construction.

CHAPTER VII. KLAMATH AND SMITH RIVER BASINS

This section is devoted to discussion of the Klamath River Basin. Although the Smith River was not studied as part of this investigation, the drainage basin boundary, stream system, and data on previously reported plans are presented herein.

The Klamath River is the third largest stream system in California, being exceeded only by the Sacramento and Colorado Rivers. It has by far the most surplus water available of any California stream. With a mean annual runoff of 12,000,000 acre-feet, the Klamath River has twice as much water as the Eel River. Even after development of the Trinity River Basin, there still would remain sufficient surplus water in the Klamath River to develop a yield of over 6 million acre-feet.

Although the Klamath River Basin has a large amount of surplus water, major water development for export out of the basin will not occur for many years. It is even possible that technological advances in other fields of water supply will make development in the Klamath Basin unnecessary. The major reasons for the later-staging of Klamath River projects are the possible damage to the anadromous fisheries, and the inherent great scale of any economic project in the basin. Since the Klamath River development is considered only as a long-range possibility, alternative plans for the basin have not been studied in as great detail as those for the earlier-staged projects.

The Smith River has the highest runoff per square mile of any river in California. With only 700 square miles of drainage area, it has an average annual runoff of 3,000,000 acre-feet. It also has the least deviation from the total mean annual runoff. This accounts for a very high ratio of firm yield to runoff. Unfortunately, it is located in the extreme northwestern part of the State and at a low elevation making the conveyance to the Sacramento Valley very difficult. Consequently, water development on this stream would follow the Klamath River.

This chapter is divided into four sections, covering the following subjects: existing water development, alternative conservation plans, alternative conveyance systems, and possible effects of water development plans.

The drainage boundaries, stream patterns, and damsite locations are shown on Figure 15. Pertinent topographic and hydrographic data referenced to damsites are presented in Table 6.

Existing Water Development

There are more existing water developments in the Klamath River Basin than on any other North Coastal stream. Besides the Bureau of Reclamation's Trinity Project, which is described in Chapter IV, the upper Klamath Basin is extensively developed. The following is a list of the principal existing reservoirs in the Klamath River Basin, excluding the Trinity River Basin.

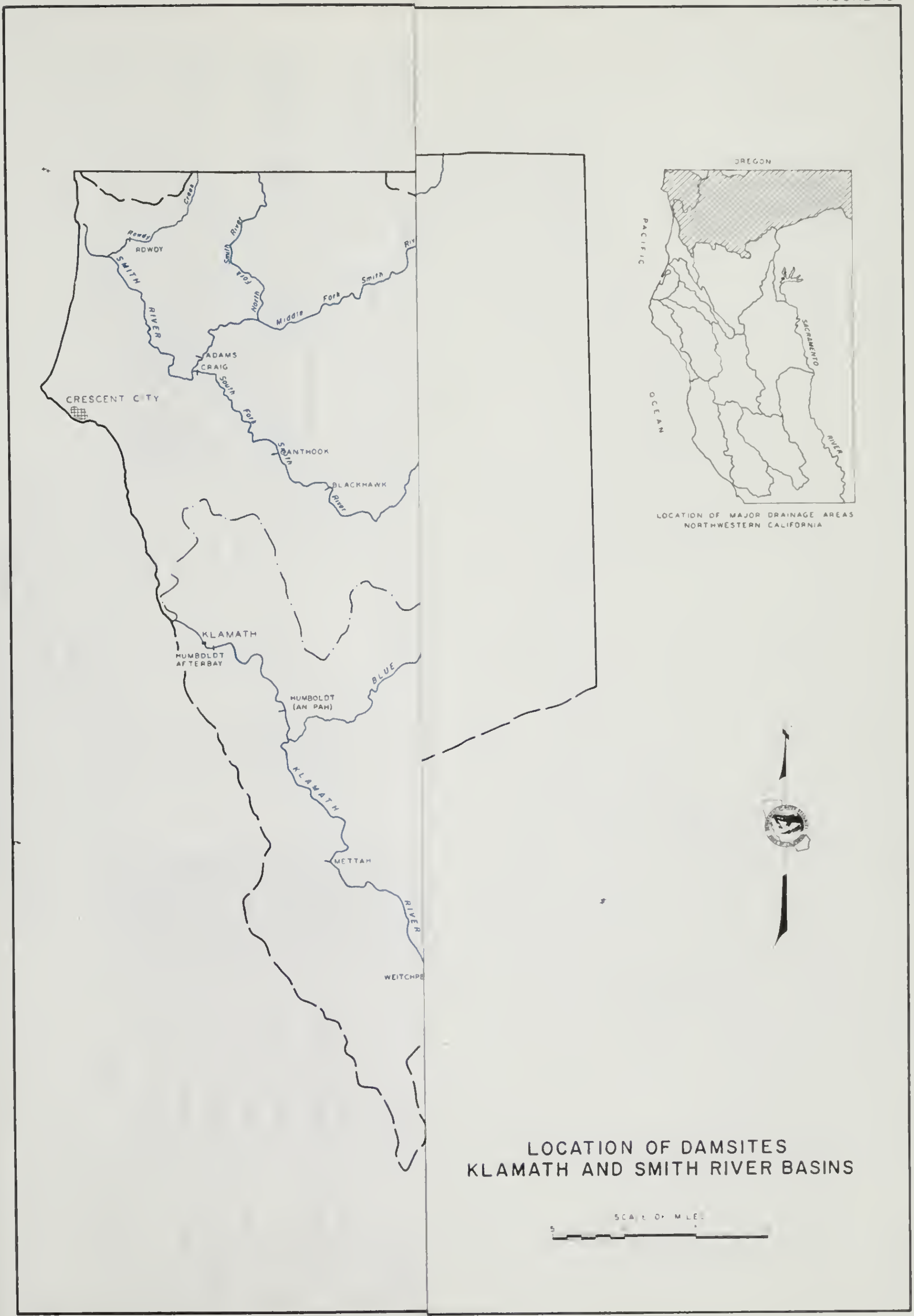
TABLE 8

EXISTING RESERVOIRS
KLAMATH RIVER BASIN

Name of Reservoir	Stream	Dam Location				Use
		Sec.	Town-ship	Range	Base & Meridian	
Dwinnell	Shasta River	25	43N	5W	MD	I
Iron Gate	Klamath River	9	47N	5W	MD	P
Copco	Klamath River	29	48N	4W	MD	P
Clear Lake	Lost River	8	47N	8E	MD	I & W
Butte (Meiss Lake)	---	--	---	--	--	I
Upper Klamath L.	Link River	30	38S	9E	W	I,P&W
Lower Klamath L.	---	--	---	--	--	I & W
Tule Lake Sump	Lost River	--	---	--	--	I & W
Gerber	Miller Creek	12	39S	13E	W	I

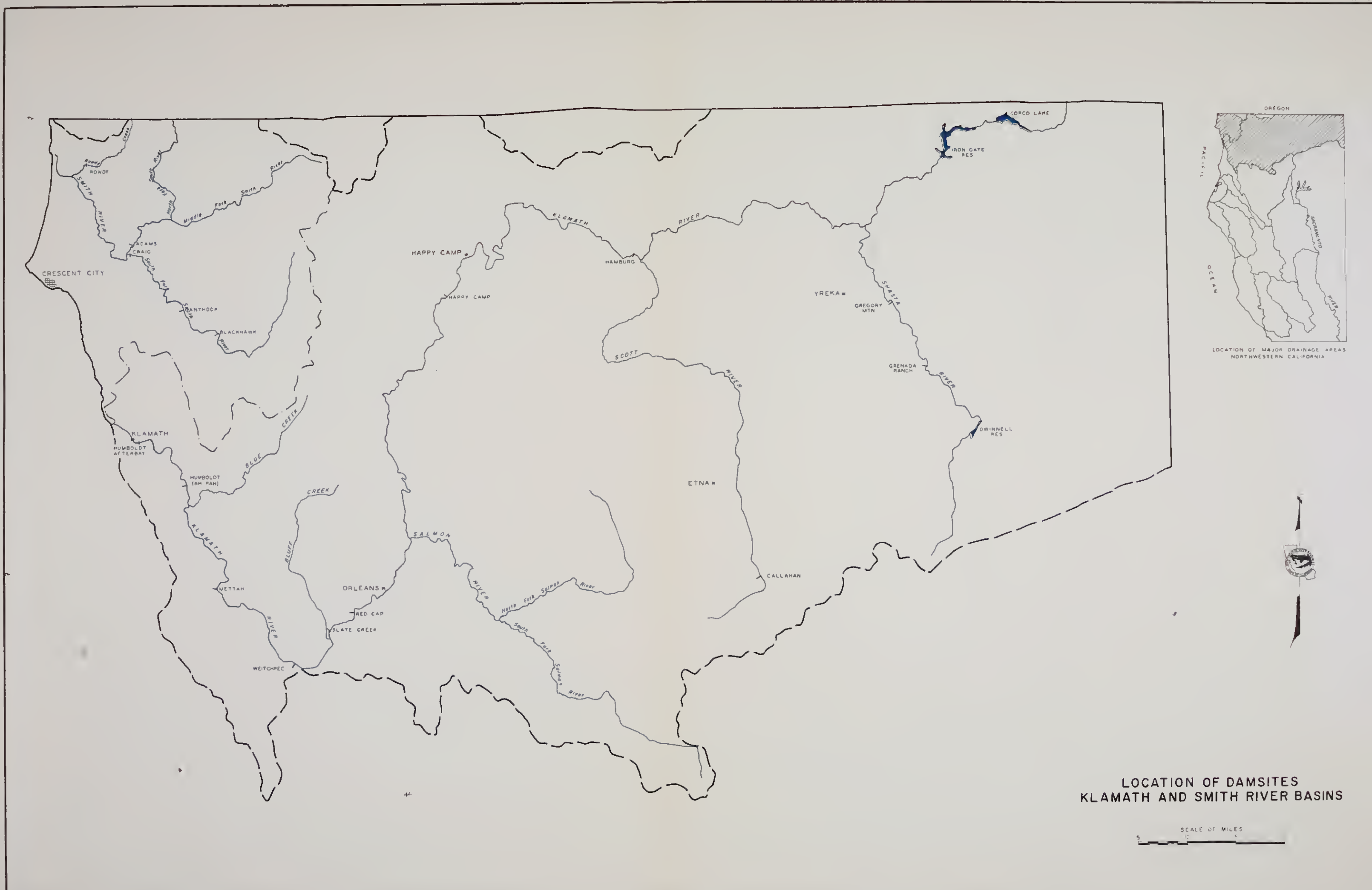
Symbols: MD = Mount Diablo
W = Willamette

I = Storage, irrigation
P = Power
W = Waterfowl refuge



LOCATION OF DAMSITES
KLAMATH AND SMITH RIVER BASINS

DEPARTMENT OF WATER RESOURCES 1964



LOCATION OF DAMSITES
KLAMATH AND SMITH RIVER BASINS

KLAMATH AND SMITH RIVER BASINS

DAMSITE TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area (SM)	50 Year Runoff (1000 AF)	Streambed Elevation	Remarks
Copco	Klamath River	S. 29, T48N, R4W, MDB&M	4,350	1,570	2,480	Existing power feature of Pacific Power & Light
Iron Gate	Klamath River	S. 9, T47N, R5W, MDB&M	4,630	---	2,155	Existing power feature of Pacific Power & Light
Hamburg	Klamath River	S. 31, T46N, R10W, MDB&M	6,855	2,800	1,520	Bul. #3 site and possible use for firming up lower Klamath.
Happy Camp	Klamath River	S. 33, T16N, R7E, HB&M	7,344	3,220	960	Bul. #3 site.
Red Cap	Klamath River	S. 10, T10N, R5E, HB&M	8,580	5,760	300	Alternate to Slate Cr., better geology.
Slate Creek	Klamath River	S. 19, T10N, R5E, HB&M	8,659	---	250	Poor geology, used in Bul. #3.
Weitchpec	Klamath River	S. 9, T9N, R4E, HB&M	11,729	---	170	Possible alternate to Humboldt site.
Mettah	Klamath River	S. 30, T11N, R3E, HB&M	---	---	80	Diversion site, used with low Humboldt.
Humboldt	Klamath River	S. 10, T12N, R2E, HB&M	12,084	12,000	40	Best site for full Klamath R. development.
Ah Pah	Klamath River	S. 10, T12N, R2E, HB&M	12,084	12,000	40	New name for Humboldt site
Humboldt Af.Ba.	Klamath River	S. 15, T13N, R1E, HB&M	---	---	0	Possible pump-back feature.
Adams	Smith River	S. 3, T15N, R1E, HB&M	317	1,398	215	Possible major storage facility.
Craigs	S.F. Smith R.	S. 10, T15N, R1E, HB&M	294	1,241	110	Possible major storage facility.
Black Hawk	S.F. Smith R.	S. 19, T15N, R3E, HB&M	116	---	720	Pump-lift for Canthook, used in Bul. 3.
Canthook	S.F. Smith R.	S. 10, T15N, R2E, HB&M	221	---	480	Very poor geology, used in Bul. 3.

As shown in the table, the main water developments are for irrigation and power generation in the semiarid area of the upper basin. This region, which includes all of the area above the Scott River confluence, including the Scott River Basin, contains 98 percent of all the irrigable lands in the Klamath River Basin. For this reason there will be very little surplus water from the upper basin after the area is fully developed.

Alternative Conservation Plans

There are a number of alternative plans for major water development on the Klamath River. Three alternative concepts are discussed in this section: staged development by a number of reservoirs, as in the California Water Plan, Bulletin No. 3; total development by a single major structure, as in the Humboldt Reservoir plan; and development by providing firming flows in the lower river from a reservoir(s) in the upper basin, as in the "Flow Maintenance Plan".

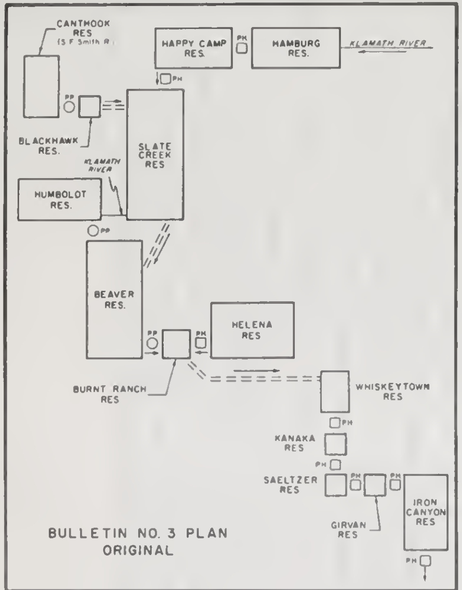
The Bulletin No. 3 plan, the Modified Bulletin No. 3 Plan and the Staging Plan, are discussed below and shown schematically on Figure 16.

Bulletin No. 3 Plan

In this plan there would be the following reservoirs: Helena, Burnt Ranch, Eltapom, Eltapom Afterbay, and Beaver on the Trinity River; Hamburg, Happy Camp, Slate Creek, and Humboldt on the Klamath River; and Canthook and Blackhawk on the Smith River. All the water developed in these reservoirs would be collected in Burnt Ranch Reservoir, from which it would be conveyed to Clear Creek via a long tunnel. Water developed on the South Fork of the Smith River at Canthook Reservoir would be pumped to Blackhawk Reservoir for conveyance by tunnel to Slate Creek Reservoir. This yield plus that of Hamburg, Happy Camp, and Slate Creek Reservoir would be diverted to Beaver Reservoir by a 10-mile tunnel. The yield of Humboldt Reservoir would be pumped into Beaver Reservoir; then all this water plus the yield from Beaver Reservoir itself would be pumped into Burnt Ranch Reservoir.

Modified Bulletin No. 3 Plan

Subsequent to formulation of the above plan, geologic investigation revealed very poor foundation conditions at Slate Creek and Canthook damsites. Consequently, the plan was modified to include Adams and Craig Reservoirs on the Smith River, and Red Cap Reservoir on the Klamath River.



BULLETIN NO. 3 PLAN
ORIGINAL

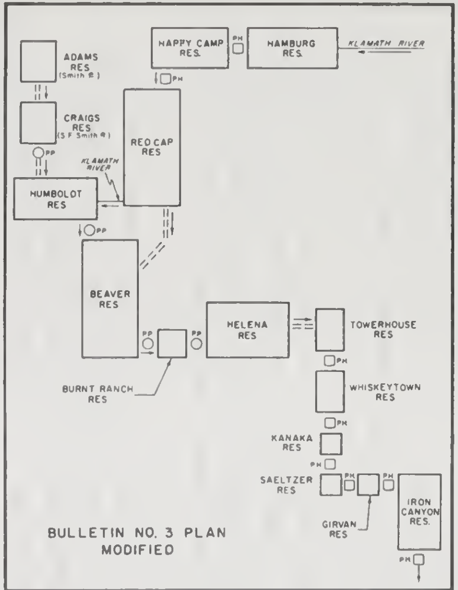
BULLETIN NO. 3 ORIGINAL

PLAN: Complete development of the Klamath River and the South Fork of the Smith Rivers.

DATA: Yield is 7,784,000 acre-feet.

DISCUSSION: Geological finding have eliminated three damsites from current consideration. Therefore, this plan cannot be compared to others, unless modified.

REFERENCE: See Bulletin No. 3 for details.



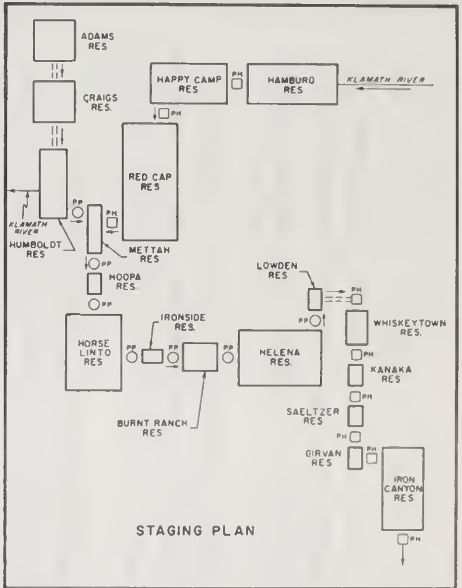
BULLETIN NO. 3 PLAN
MODIFIED

BULLETIN NO. 3 MODIFIED PLAN

PLAN: Similar to the original plan, except Red Cap replaces Slate Creek Dam, Adams and Craig Dams replaces Canthook and Blackhawk Dams, and Smith River water would be pumped into Humboldt instead of to Slate Creek.

DATA: Yield is 8,900,000 acre-feet.

DISCUSSION: This plan yields more water than the original plan because the Smith River dams control the whole river, rather than just the South Fork.



STAGING PLAN

STAGING PLAN

PLAN: Complete development of the Klamath and Smith River Basins in stages.

DATA: Yield of the two rivers, 6,700,000 acre-feet

DISCUSSION: The first two stages are on the Trinity River. The last stage is on the Smith River.

ALTERNATIVE PLANS FOR THE DEVELOPMENT
AND
CONVEYANCE OF THE KLAMATH RIVER

Staging Plan

Although the two previously described plans are somewhat susceptible to staging, they were not formulated with staging in mind. The following plan, formulated in 1959, was designed for staging. It is illustrated schematically in Figure 16.

The plan assumes the prior construction of certain features on the upper Trinity River. These features which were discussed as one of the alternatives in the previous chapter, include Helena, Burnt Ranch, and Horse Linto Reservoirs.

The first stage of works which would tap the Klamath River directly would include Hamburg, Happy Camp, Red Cap, and Mettah Reservoirs on the Klamath River and Hoopa Reservoir on the Trinity River. Hamburg and Happy Camp Dams and Reservoirs would be primarily for hydroelectric generation. The major conservation feature, Red Cap Dam and Reservoir, would also include hydroelectric facilities. Mettah Dam and Reservoir would function primarily as a diversion feature and would back water up to Hoopa Dam. Hoopa Reservoir, which would not inundate Hoopa Valley, would function as a conveyance feature and would back water up to Horse Linto Dam. Pumping plants would be required at Hoopa, Horse Linto, Burnt Ranch, and Helena Dams. The works of this stage would develop 3,000,000 acre-feet of annual yield.

The second stage of development under this plan, which would be the fourth or fifth stage when the entire Klamath Basin is considered, would include a major diversion from the Smith River. Development of the Smith River was not proposed in Bulletin No. 136; however, alternative plans for its development have been studied in the past and they are presented here as a matter of record. Two dams near the mouth of the Smith River would be used for storage along with Humboldt Reservoir. Adams Reservoir, located on the main stem of the Smith River, and Craig Reservoir located on the South Fork of the Smith River would be connected by an ungated tunnel 1.3 miles long. From Craig Reservoir a 21-mile long tunnel would convey water to Humboldt Reservoir. In this plan Humboldt Reservoir would have a normal water surface of 310 feet and a minimum of 85 feet, which is streambed at Mettah damsite. Water would be pumped from Humboldt to Mettah, then to Hoopa and on up to Trinity River. The yield of the second stage would be about 1,875,000 acre-feet.

This plan was not studied in as much detail as the Humboldt Reservoir Plan. It appears that the unit cost of yield from this plan would be somewhat greater than the single reservoir plan, particularly for the higher yields. This is because the cost of storage at the many reservoirs is considerably more than for one large reservoir. However, no detailed analysis has been made of the plan from the standpoint of meeting a projected rate of demand buildup. Under a long period of demand buildup, the staging plan could possibly be more favorable than the Humboldt Reservoir Plan.

Humboldt Reservoir Plan

From the standpoint of developing a large amount of water at a reasonable unit cost, a plan utilizing a single large reservoir on the lower Klamath River appears favorable. For this reason, the Humboldt Reservoir Plan was shown in Bulletin No. 136 as a favorable plan of development.

Humboldt Reservoir, which is the sole conservation storage feature of the plan, would be created by a large dam on the Klamath River below the confluence of Blue Creek. This is about 12.5 miles above the mouth of the river. The minimum water surface elevation to develop yield for export would be above 600 feet. This is the streambed elevation of Ironside Dam on the Trinity River, which would be one of the conveyance features. For an annual yield of 6,000,000 acre-feet, a dam 740 feet high is required. The normal water surface of the reservoir created would be 765 feet. Physical and cost data for this plan are shown on Plate No. 20.

In addition to the fishery problem, which all of the Klamath River plans have, there is a major problem of project repayment during the demand buildup period.

One possibility which was analyzed in connection with this project would be to generate hydroelectric peaking capacity by utilizing the head differential between the water surface of Humboldt Reservoir and the streambed elevation. If Humboldt Reservoir were sized to yield 6,000,000 acre-feet per year, the mean powerhead would be 664 feet. With this head and water yield, 1,300,000 kilowatts of dependable power could be generated. All of the generating units would be reversible, that is, generators would act as motors and turbines would become pumps. In this manner 70 percent of the water could be pumped back, provided that an afterbay of sufficient capacity were constructed.

From the first year of the project until the water demand reaches 70 percent of the yield, the plant would generate its full installed capacity. After the water demand exceeds 70 percent of the yield, one of two possible means must be employed: either install additional straight pumps or decrease the generating capacity. If the pump units are added, the capacity of the straight pump units would have to be about 43 percent of the capacity of the reversible units when the full demand is developed.

Flow Maintenance Plan

One possible way to develop surplus water from the Klamath River would be to divert flows from a low diversion structure near the mouth through some manner of conveyance system. The conveyance system might be a series of channels and reservoirs leading to the Eel River; or possibly some form of conduit along the coastline. Divertible flows would be maintained in the lower Klamath River by constructing storage facilities in the upper reaches of the river.

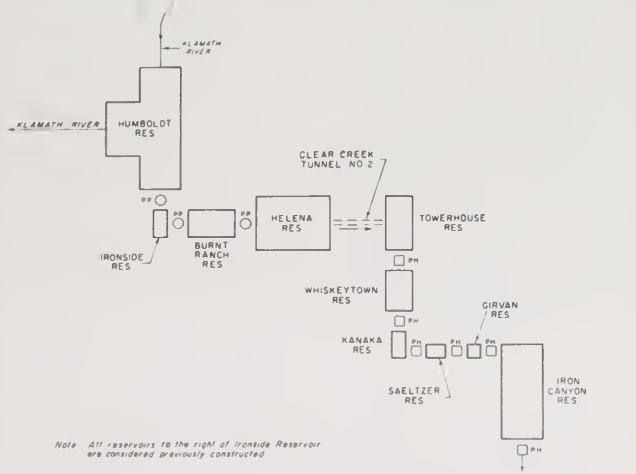
This type of plan has received no more than cursory examination. However, the increasing concern for the river's fish and wildlife resources has pointed to the future necessity of considering such unconventional plans, in the hope that major detriments could be avoided.

Alternative Conveyance Systems

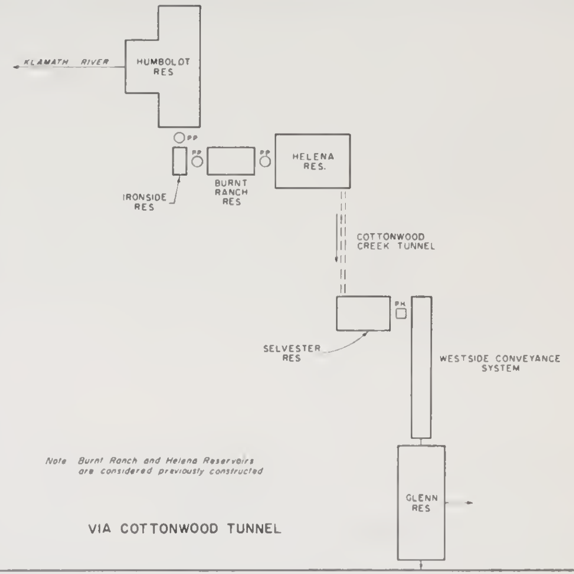
There are a number of alternative plans by which water developed on the Klamath River might be conveyed to the Sacramento River Basin. The plans can be considered in two classes: those that involve a series of pump lifts up the Trinity River and those that involve a single long tunnel. In addition, it may be possible, as mentioned above, to convey water south to the Eel River and pump it up that stream.

Pump-Lift Plans

In this plan, which is illustrated in Figure 17, the possible alternatives can be considered in two groups; the alternative features which could be used to lift the water up through the Trinity River Basin to a forebay reservoir below Lewiston Dam; and the alternative conveyance routes for transferring the water from the forebay reservoir on the Trinity River to the lower Sacramento River Basin.



VIA CLEAR CREEK TUNNEL



VIA COTTONWOOD TUNNEL

CLEAR CREEK CONVEYANCE ROUTE

Plan: To divert water from Humboldt Reservoir to Iron Canyon Reservoir, utilizing previously constructed power dams on Clear Creek to generate large blocks of power.

Discussion: This plan appears the most economical when the power values indicated below are used in the analysis. Iron Canyon Reservoir would not have sufficient storage to provide for conjunctive operation with the Delta.

COTTONWOOD CREEK CONVEYANCE ROUTE

Plan: To divert water from Humboldt Reservoir to Glenn Reservoir utilizing previously constructed works.

Discussion: By utilizing storage in Glenn Reservoir the yield of Humboldt Reservoir can be increased substantially.

PLAN: Full development of the Klamath River by one large dam near the mouth -- four alternate export routes

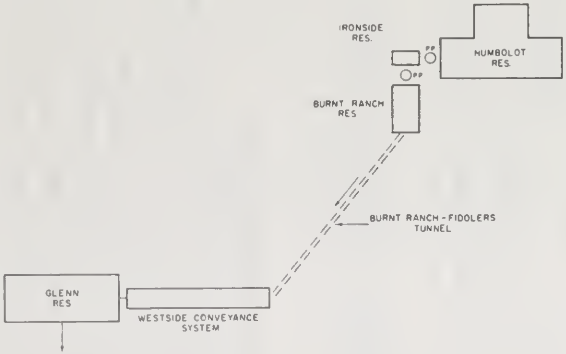
Conveyance Route	Delta Yield 1,000 A.F.	Terminal Storage Reservoir	Tunnel Length in miles	Tunnel Elevation Intake	Tunnel Elevation Outlet	Cost $10[6] Capital	Cost $10[6] Annual	Unit Cost $/acre-foot	Features Assumed Previously Constructed	Power and Pumping Criteria Used
Clear Creek	6,[illegible]00	Iron Canyon	12	1,650'	1,6[illegible]'	$1,511	$ 41.8	$ 6.97	Burnt Ranch, Helena, Iron Canyon and Clear Creek conveyance facility	Value of dependable capacity $[illegible]/KW year
Cottonwood Creek	[illegible]	Glenn Complex	20	1,500'	1,400'	1,[illegible]00	73.4	10.64	Burnt Ranch, Helena, Selvester, Westside Conveyance System and Glenn	Value of energy generated 3 mills/KWH
Burnt Ranch-Fiddlers Tunnel	6,900	Glenn Complex	35	1,200'	1,000'	1,112	70.6	10.23	Westside Conveyance System and Glenn	Value of energy for pumping 3.3 mills/KWH
Humboldt-Iron Canyon Tunnel	6,000	Iron Canyon	65	600'	400'	1,319	65.9	10.98	Iron Canyon	

Discussion: Develops the most water from the Klamath River. Unit cost is lowest for large yields. Staging is the most difficult.
Reference: See summary plates [illegible], 8, 8a, 9, [illegible]a, 10b, 1[illegible], and 20.

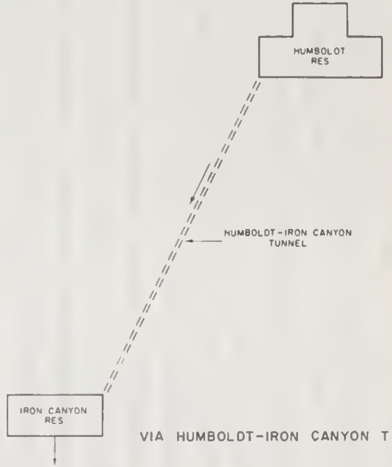
HUMBOLDT RESERVOIR PLANS
ALTERNATIVE CONVEYANCE ROUTES

FIGURE 17

DEPARTMENT OF WATER RESOURCES 1964



VIA BURNT RANCH-FIDDLERS TUNNEL



VIA HUMBOLDT-IRON CANYON TUNNEL

BURNT RANCH-FIDDLERS TUNNEL ROUTE

Plan: To export water from Humboldt Reservoir to Glenn Reservoir without going through Helena Reservoir.

Discussion: This plan is compatible with Trinity River plans which do not include Burnt Ranch Reservoir. Burnt Ranch would have a constant water surface elevation of 1,200 feet, which is below the streambed at Helena. Routing through Glenn Reservoir increases the yield, as releases would be made to the Delta in conjunction with surplus flows.

HUMBOLDT-IRON CANYON TUNNEL ROUTE

Plan: To get water from Humboldt Reservoir to the Sacramento Valley by gravity.

Discussion: This plan will receive further consideration if tunneling costs decrease or if the value of power generated by the Clear Creek Powerplants decreases in the future.

The delivery of water to Iron Canyon Reservoir does not provide any increase in yield due to the limited storage there.

PLAN: Full development of the Klamath River by one large dam near the mouth -- four alternate export routes

Conveyance Route	Delta Yield 1,000 A.F.	Terminal Storage Reservoir	Tunnel Length in miles	Tunnel Elevation Intake	Tunnel Elevation Outlet	Cost $10⁶/ Capital	Cost Annual	Unit Cost $/acre-foot	Features Assumed Previously Constructed	Power and Pumping Criteria Used
Clear Creek	6,000	Iron Canyon	1[illegible]	1,650'	1,600'	$1,511	$ 41.8	$ 6.97	Burnt Ranch, Helena, Iron Canyon and Clear Creek conveyance facility	Value of dependable capacity $[illegible]/KW-year
Cottonwood Creek	6,000	Glenn Complex	20	1,500'	1,400'	1,300	73.4	10.64	Burnt Ranch, Helena, Selvester, Westside Conveyance System and Glenn	Value of energy generated 3 mills/KWH
Burnt Ranch-Fiddlers Tunnel	6,900	Glenn Complex	35	1,200'	1,000'	1,112	70.6	10.23	Westside Conveyance System and Glenn	Value of energy for pumping 3.3 mills/KWH
Humboldt-Iron Canyon Tunnel	6,000	Iron Canyon	65	600'	400'	1,319	65.9	10.98	Iron Canyon	

[illegible] Develops the most water from the Klamath River. Unit cost is lowest for large yields. Staging is the most difficult.
Reference: See summary plates 3, 8, 8a, 9, 1[illegible]a, 10b, [illegible]2, and [illegible].

HUMBOLDT RESERVOIR PLAN
ALTERNATIVE CONVEYANCE ROUTES

From staging considerations, Trinity River development would precede Klamath River development by quite a number of years. The effect of this would be that the dams and reservoirs through which Klamath River water would be lifted would be in existence. The only features which have been studied which would probably be incompatible with each other from this standpoint are Horse Linto Dam and Reservoir and a large Humboldt Dam and Reservoir. The streambed elevation at Horse Linto damsite is approximately 300 feet above the elevation at Humboldt damsite.

It is presently envisioned that Helena Reservoir would be the Trinity River forebay for diversion to the Sacramento River Basin. There are two alternative routes for accomplishing the diversion: either by tunnel to Clear Creek, or by tunnel to Cottonwood Creek, the Westside Conveyance System, and Glenn Reservoir. Both routes are discussed in Chapter III.

Long Tunnel Plans

Two plans were analyzed in which diversion to the Sacramento River Basin would be accomplished by a very long tunnel. These two plans, which are illustrated in Figure 18, are described briefly below. Physical and cost data for the tunnels is summarized on Plate No. 20.

Burnt Ranch-Fiddlers Tunnel Route. In this plan water would be pumped from the Klamath River into Burnt Ranch Reservoir. A 35-mile tunnel would convey the water to Fiddlers Reservoir on Cottonwood Creek. From Fiddlers Reservoir, the water would be conveyed through the Westside Conveyance System to the Glenn Reservoir Complex.

Humboldt-Iron Canyon Tunnel Route. In this plan a 65-mile tunnel would convey the water from Humboldt Reservoir to Iron Canyon Reservoir on the Sacramento River.

Possible Effects of Water Development Plans

It is recognized that construction of a major water development project on the lower Klamath River would present serious problems. Probably the most talked-about problem is that of the effect on anadromous fisheries. Other problems include inundation of scarce flat lands, possible acquisition of Indian reservation land, inundation of valuable timber land, and inundation of extensive game habitat. The planning studies to date have been only of a reconnaissance nature and have been directed towards evaluation of physical parameters and the fisheries problem.

CHAPTER VIII. RUSSIAN RIVER BASIN

The Russian River originates in southeastern Mendocino County. It flows southerly into the central portion of Sonoma County, then turns westerly and terminates in the Pacific Ocean at Jenner, California. The river has a length of about 115 miles, a drainage area of 1,498 square miles and a mean annual natural runoff of 1,470,000 acre-feet. The Russian River Basin contains 246 square miles of valley and mesa lands. These lands have been developed into highly productive orchards and vineyards and contain most of the population of Mendocino and Sonoma Counties. The Northwestern Pacific Railroad and U. S. Highway 101 lie adjacent to the river between Capella and Healdsburg, a distance of 45 miles.

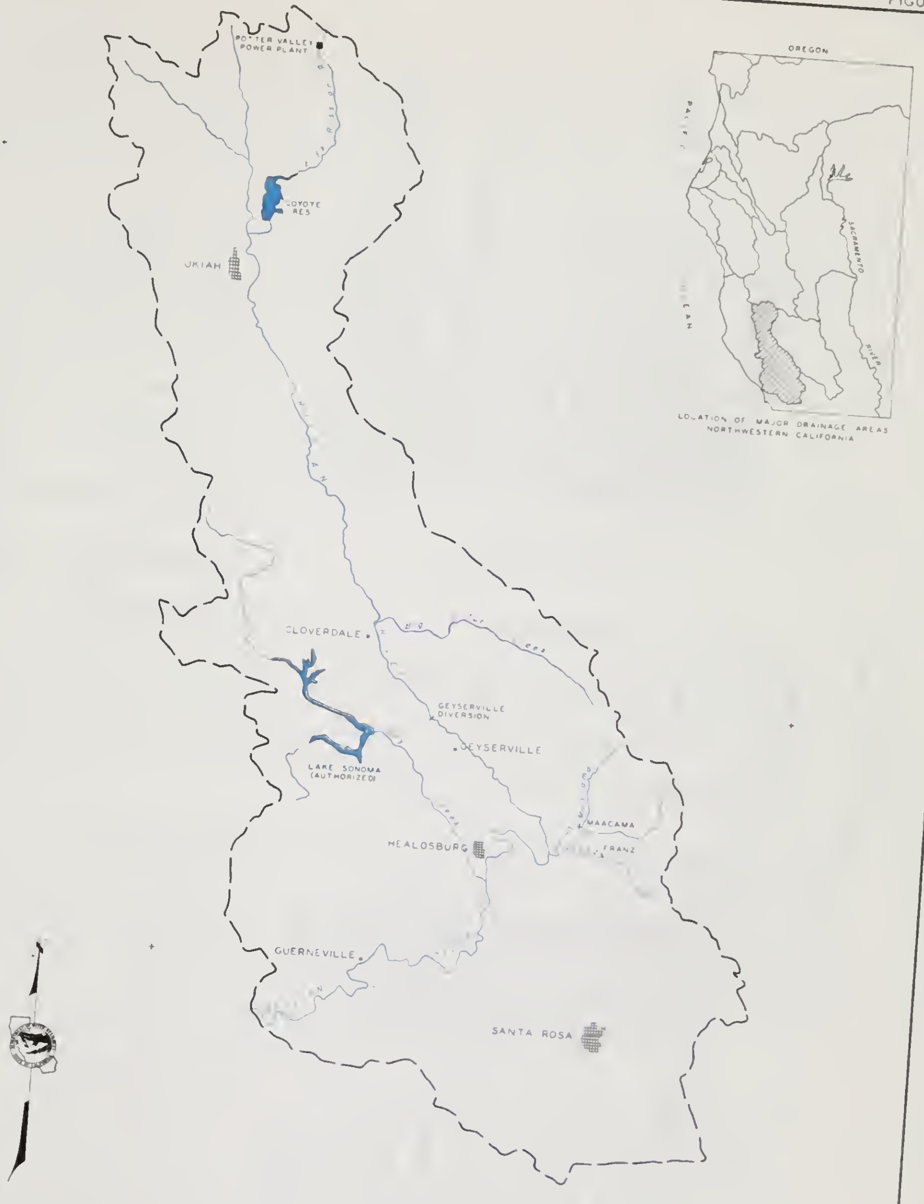
In addition to its natural runoff the Russian River receives water from the Eel River. The Pacific Gas and Electric Company makes a diversion through the Van Arsdale diversion facilities into the Potter Valley Powerhouse on the East Fork of the Russian River. The diversions through the present facilities average about 167,000 acre-feet per year.

Present Development

Coyote Dam, which forms Lake Mendocino, was constructed on the East Fork Russian River near Ukiah by the U. S. Corps of Engineers in 1959. Lake Mendocino has a gross capacity of 122,500 acre-feet and a normal pool elevation of 765 feet. Forty-eight thousand acre-feet of storage is reserved for flood control; 70,000 acre-feet is used for water conservation, and the lake has a dead storage pool of 4,500 acre-feet. The project develops a firm annual yield of 87,000 acre-feet, of which 60,000 acre-feet is used consumptively. This water supply is derived principally from the reregulation of the water diverted from the Eel River. The natural runoff tributary to the damsite averaged 33,400 acre-feet per year during the dry period of May 1928 through December 1934. In addition to providing a firm water supply, the reservoir is operated to maintain the flow in the Russian River at not less than 150 cubic feet per second at the mouth of the East Fork and not less than 125 cubic feet per second at Guerneville.

The Sonoma County Flood Control and Water Conservation District owns and operates a system of diversion works from the Russian River. The

FIGURE 19



LOCATION OF DAMSITES
RUSSIAN RIVER BASIN

TABLE 10

RUSSIAN RIVER BASIN

PARTIAL TOPOGRAPHIC AND HYDROGRAPHIC DATA

Dam Name	Stream	Location	Drainage Area ( )	50 Year Runoff (1000 AF)	Stream Bed Elevation	Remarks
Coyote	E.F. Russian R.	1 mi. above junction w/main stem	105	84	620	Existing USCE structure, can be enlarged.
Big Sulphur Cr. Diversion	Big Sulphur Creek	S. 5, T11N, R10W, MDB&M	82	126	320	Possible diversion feature of Knights Valley Project
Cloverdale Diversion	Russian R.	S. 25, T12N, R11W, MDB&M	502	713	330	Possible diversion feature of Knights Valley Project
Geyserville D.	Russian R.	3½ mi. above Geyerville	---	---	230	Possible diversion feature of Knights Valley Project
Knights Valley	Maacama Cr.	S. 9, T9N, R8W, MDB&M	60	80	215	Proposed off-stream storage site by the USCE & USBR, susceptible to stage development.
	Franz Cr.	S. 23, T9N, R8W, MDB&M			265	
Maacama Forebay No. 1	Maacama Cr.	1 mi. above junction w/Russian R.	---	---	155	Pumping forebay for Knights Valley
Maacama Forebay No. 2	Maacama Cr.	S. 9, T9N, R8W, MDB&M	---	---	190	Pumping forebay for Knights Valley
Healdsburg Diversion	Russian R.	½ mi. upstream of Maacama Cr.	793	1,000	120	Possible diversion & pumping forebay for Knights Valley
Warm Springs	Dry Creek	S. 18, T18N, R11W, MDB&M	130	145	202	Authorized USCE flood control project
Molinos Div.	Russian R.	S. 28, T8N, R9W, MDB&M	---	---	45	Possible diversion feature for comprehensive development of Russian River.
Laguna	Laguna DeSanta Rosa	S. 34, T8N, R9W, MDB&M	---	---	40	Off-stream storage site for comprehensive development of Russian River.

system includes two pumping units located in the river approximately 1 mile upstream from the junction with Mark West Creek, and a pipeline via Santa Rosa to Petaluma. The system has a diversion capability of about 45,000 acre-feet per year.

In addition to these existing works, the U. S. Corps of Engineers is in the advanced planning stage of its studies of the Warm Springs Dam and Reservoir project on Dry Creek. This project, which has received congressional authorization for construction, would provide flood protection, fish enhancement, recreation and a firm water supply of 90,000 acre-feet per year, primarily to lower Sonoma and Marin Counties. The reservoir, named Lake Sonoma, would be about 6 miles south of Cloverdale and would have a gross capacity of 277,000 acre-feet. Construction on this multiple-purpose project is expected to commence prior to 1970.

Knights Valley Project

Departmental planning efforts in the Russian River Basin have been directed toward a possible water development project at Knights Valley. The purpose of the project would be to conserve the natural flows of Maacama and Franz Creeks and to provide storage for surplus flows diverted from the Russian River. The conserved water would be used in the Napa and Russian River Basins.

The Knights Valley Reservoir site has a storage potential of about 1.6 million acre-feet. This large storage reservoir could be formed by the construction of two dams. One would be located on Maacama Creek and would be about 411 feet high. The other would be a 321-foot high structure on Franz Creek. Only about 240,000 acre-feet of this storage potential would be needed to conserve the natural flows of Maacama and Franz Creeks, which are 66,000 and 14,000 acre-feet per year, respectively.

The purpose of constructing a large reservoir at this site would be to provide storage for surplus flows diverted from the Russian River. There are three practical physical plans by which this diversion could be accomplished. Each would require a diversion dam on the Russian River, a conveyance canal to the reservoir, and a pumping plant at the reservoir. The Department's studies indicate that the most favorable plan would include a diversion dam near Geyserville and a 17-mile long canal to the forebay and pumping plant. An analysis of the relationship between cost, diversion capacity and reservoir storage capacity for the three alternative diversion systems is presented on summary Plate No. 14.

The Knights Valley Project could be constructed either in stages or to its full potential initially. The Department's present studies indicate that staged development would be a more favorable utilization of investment capital. The decision as to which type of development to undertake will depend largely on the rate of demand buildup for project services. Under ultimate development the large reservoir could provide between 275,000 and 350,000 acre-feet of new annual yield, the actual amount dependent upon the conveyance capacity of the diversion facilities.

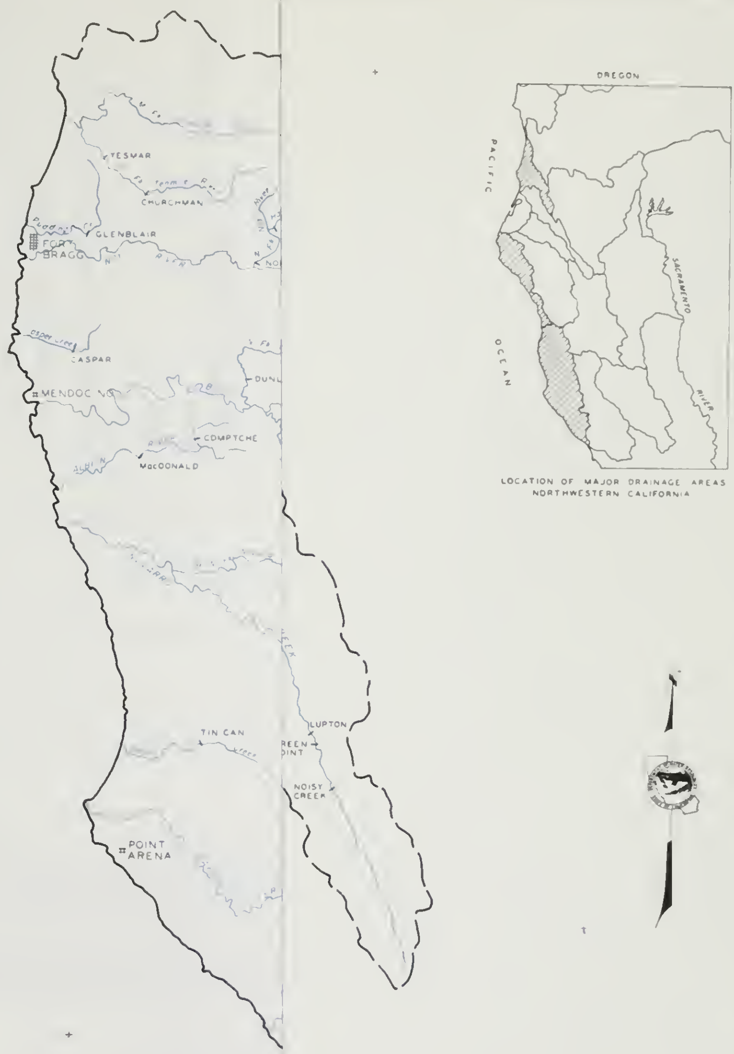
CHAPTER IX. COASTAL STREAM BASINS

In addition to project formulation studies for major developments in the interior basins of the North Coastal region, reconnaissance studies have been made of the potential for water resources development in the smaller basins. The studies of the large interior basins such as the Eel, Trinity, and Klamath, were oriented toward major multipurpose projects to meet both local and out-of-basin requirements. Studies of the coastal basins were principally concerned with locally oriented projects for recreation and fisheries enhancement.

The coastal basins investigated include the major secondary drainages north of the Russian River Basin. They are, in a north to south order: Redwood Creek, and Little, Bear, Mattole, Ten Mile, Noyo, Big, Albion, Navarro, Garcia, and Gualala Rivers. The drainage boundaries, stream patterns, and damsite locations are shown on Figure 20.

General Description

Description of Area. The coastal basins encompass an area of 3,000 square miles. They account for about 4,500,000 acre-feet of surface water runoff, or 15 percent of the total of the North Coastal area. The water resources of the basins are undeveloped, although many streams provide excellent fish habitat in their natural state. The excellent fishing in these streams, combined with the serenity of the redwoods and the rugged beauty of the coastline, offers unparalleled recreation opportunity.



MENDOCINC

LOCATION OF DAMSITES
COASTAL STREAM BASINS

LOCATION OF DAMSITES
COASTAL STREAM BASINS

Dam Name	Stream	Location	Drainage Area ([illegible])	50 Year Runoff (1000 A.F.)	Streambed Elevation	Remarks
Rowdy Creek	Tributary of Smith River	Sec. 30, T18N R1E, HB&M	30	90	60	For firming-up Smith River, for use in the Smith River Plain
Noisy Creek	Redwood Creek	Sec. 26, T6N, R3E, HB&M	61	158	1050	Known also as Christmas; possible fish enhancement
Lupton	" "	Sec. 10, T6N, R3E, HB&M	76	195	820	Possible fish enhancement
Green Point	" "	Sec. 14 & 15 T6N, R3E, HB&M	74	191	840	Alternate to Lupton, considered inferior
Crannel	Little River	Sec. 9, T7N, R11E, HB&M	43	101	75	For local water supply
Tiptop	" "	Sec. 2, T7N, R1E, HB&M	29	70	220	Possible fish enhancement reservoir
Brushy Creek	Bear River	Sec. 7, T1S, R1E, HB&M	14	43	1230	Same
Thorn	Mattole River	Sec. 22, T5S, R2E, HB&M	12	34	1120	Same
Jewett	Tributary of Mattole River	Sec. 12, T4S, R1E, HB&M	20	63	650	Same
Yesmar	North Fork Ten Mile River	Sec. 14, T19N, R17W, MDB&M	31	27	0	Together with Glennblair would supply water for local use
North Fork Ten Mile	North Fork Ten Mile River	Sec. 14, T20N R16W, MDB&M	15	23	390	Possible fish enhancement reservoir
Booth	Middle Fork Ten Mile River	Sec. 1, T19N, R16W, MDB&M	14	22	330	Same
Dutchman	South Fork Ten Mile River	Sec. 23, T19N, R16W, MDB&M	16	25	300	Same. Known also as So. Fk. Ten Mile
Churchman	South Fork Ten Mile River	Sec. 20, T19N, R16W, MDB&M	24	35	120	Same
Glennblair	Pudding Creek	Sec. 3, T18N, R17W, MDB&M	16	22	0	Combines with Yesmar, for local water supply
Hayworth #3	North Fork Noyo River	Sec. 9, T18N, R15W, MDB&M	22	33	350	Possible fish enhancement reservoir
Northspur	North Fork Noyo River	Sec. 8, T18N, R15W, MDB&M	25	37	330	Same, alternate to Hayworth
Brandon	South Fork Noyo River	Sec. 30, T18N, R16W, MDB&M	23	29	110	Same
Caspar	Caspar Creek	Sec. 9, T17N, R17W, MDB&M	--	--	100	For local water supply
Dunlap	North Fork Big River	Sec. 17, T17N, R15W, MDB&M	33	46	275	Possible fish enhancement reservoir
Hellgate	South Fork Big River	Sec. 13, T16N R15W, MDB&M	38	53	400	Same
McDonald	Albion River	Sec. 17, T16N R16W, MDB&M	--	--	50	For local water supply
Comptche	" "	Sec. 2, T16N, R16W, MDB&M	5	6	220	Possible fish enhancement reservoir
Castle Gardens	S.Branch, N.F. Navarro R.	Sec. 13, T15N R15W, MDB&M	21	25	390	Same
Lone Tree	Tributary of Navarro River	Sec. 14, T14N R14W, MDB&M	28	35	560	Same
Big Foot	Rancheria Trib of Navarro R.	Sec. 30, T12N, R12W, MDB&M	14	14	940	Same
Rector	Rancheria Trib. of Navarro R.	Sec. 25, T13N R14W, MDB&M	43	40	580	Same, alternate to Big Foot

TABLE 11 (Contd)
COASTAL STREAM BASINS

[illegible]GRAPHIC AND HYDROGRAPHIC DATA

				50 Year		
Dam Name	Stream	Location	Drainage Area (SM)	Runoff (1000 AF)	Streambed Elevation	Remarks
Tin Can	Alder Creek	Sec. 11, T13N, R16W, MDB&M	--	--	500	For local water supply
Garcia	Garcia River	Sec. 12, T12N, R14W, MDB&M	16	29	840	Possible fish enhancement reservoir
Billings	North Fork Gualala River	Sec. 34, T12N R14W, MDB&M	17	35	500	Same
Neese Ridge	Wheatfield Fk. Gualala River	Sec. 31, T10N, R12W, MDB&M	34	64	335	Same
Houser Bridge	South Fork Gualala River	Sec. 22, T9N, R13W, MDB&M	26	50	325	Same

Purpose of Studies. It is anticipated that development of these coastal streams to supply out-of-basin water demands would not be economical and will not be necessary. Inasmuch as the projected water requirements within these basins are relatively small, the major justification for coastal stream projects may be dependent on benefits from fisheries enhancement and, to a lesser extent, recreation. Therefore, studies were directed toward the selection of the more favorable fisheries enhancement projects in each basin. In addition to providing fisheries enhancement flows, these reservoirs could provide supplemental water supplies for local agricultural and urban uses.

Some of the fisheries enhancement projects on the coastal streams may offer economical opportunities for compensating possible fisheries detriments associated with the large multipurpose projects on the Eel, Trinity, and Klamath Rivers. The association of the coastal basin projects with major developments located in the interior basins could possibly provide a means for financing these smaller projects.

Scope of Studies. Three general guidelines were used in selecting the location of possible fisheries enhancement projects on the coastal streams. The reservoirs should be located: (1) in the headwaters of the stream so as to enhance the greatest possible length of stream; (2) where the runoff is sufficient to develop the enhancement releases; (3) such that reservoir inundation of spawning areas is kept to a minimum.

Department of Fish and Game Contract Services Unit furnished very preliminary information relative to: (1) an opinion as to which coastal streams possess the greatest potential for fisheries enhancement; (2) estimates of flow distribution most likely to contribute toward fisheries enhancement in these streams; and (3) estimates of what the ideal fisheries enhancement flows for each of the streams might be. In reference to (1) above, the streams selected are, in priority: Mattole, Little, Noyo, Big, and Navarro Rivers. Detailed information on fisheries is presented in the Appendix C to Bulletin No. 136, Fish and Wildlife.

The general approach to the study of the coastal basins was to review all available data and select one or more promising reservoir sites in each of the basins. Reservoir yield-capacity and cost-capacity relationships were then developed for each of these sites. The yield-capacity relationships were based on distribution of yield corresponding to schedules provided by Department of Fish and Game. The cost-capacity relationships were based on average unit capital cost values applied to estimated embankment volumes, which in most cases were developed from 1:62,500 quadrangles. Yield-cost relationships were then developed, from which the most promising sites in each basin were selected. Another parameter, the cost per acre-foot per mile, was also developed as an aid in the selection of projects.

Summary of Results. Table 12 shows cost and yield estimates for selected projects in each basin. The table also shows the unit cost of yield for the "ideal enhancement flows", the length of stream enhanced, and the unit cost of yield per mile. The purpose of the table is for comparison only. A priority of projects cannot be established until much additional study is made of fisheries enhancement benefits on each of the streams.

The intensity of the study conforms to rough reconnaissance standards; consequently, the results should be viewed as comparative indices to topographic and hydrologic suitability of the various projects rather than absolute measures of cost.

TABLE 12

COASTAL STREAMS
POSSIBLE PROJECTS FOR FISHERIES ENHANCEMENT

Stream	Dam and Reservoir	Reservoir Capacity in 1,000 Acre-Feet	Annual Yield 1,000 AF	Capital Cost	Annual Unit Cost of Yield $ per AF	Length of Stream Enhanced in Miles	Unit Cost of Yield per Mile of Stream ($ per AF per Mile)
Redwood Creek	Lupton	20	43	$ 3,900,000	4.50	43	0.10
Little River	Tiptop	4	6	400,000	4.00	7	0.60
Bear River	Brushy Creek	10	15	3,900,000	13.00	22	0.60
Mattole River	Thorn and Jewett	24 32	20 31	6,600,000 2,900,000	10.00	61	0.40
Ten Mile River	Churchman	50	26	10,400,000	20.00	10	2.00
Noyo River	Northspur	6	7	800,000	7.00	23	0.30
Big River	Dunlap	20	14	2,200,000	8.00	36	0.20
Albion River	Comptche	8	2	800,000	20.00	14	1.40
Navarro River	Rector	18	16	3,200,000	10.00	46	0.20
Garcia River	Garcia	4	6	1,700,000	14.00	35	0.40
Gualala River	Neese Ridge	10	15	3,000,000	10.00	31	0.30

Related Studies

Department of Water Resources. The coastal basins were studied and possible developments were reported in Bulletin No. 3. These studies were restricted to rough reconnaissance appraisals, and no attempt was made to evaluate fisheries enhancement benefits. Subsequent to Bulletin No. 3, a brief study was made to determine the merits of transporting Eel River water to the Sacramento-San Joaquin Delta via a coastal aqueduct route. Information on land and water use have been compiled for the coastal basins under the Coordinated Statewide Planning Program.

Federal Agencies. The U. S. Corps of Engineers has conducted flood control studies on Redwood Creek. With this exception, neither the Corps nor the Bureau of Reclamation has made studies of possible water development projects on the coastal streams.

The U. S. Fish and Wildlife Service has made studies of some of the coastal streams, and preliminary estimates of present fish and wildlife resources are published in an appendix to the Pacific Southwest Field Committee Report. Estimates of fisheries enhancement potential, in terms of numbers of fish each stream can accomodate, are also presented in that appendix. This information is available for Redwood Creek, Little River, Bear River, and Mattole River.

Possible Plans for Development

A brief description of possible developments on each of the coastal streams follows.

Redwood Creek. According to the U. S. Fish and Wildlife Service, Redwood Creek is accessible to salmon for about 48 miles of its 63-mile length. Major spawning activity for King and Coho salmon takes place in the middle and upper reaches of the main stem. Prairie Creek, Lacks Creek, and Minor Creek are tributaries of major importance for spawning. Steelhead trout spawn in accessible headwaters throughout the drainage basin. Estimated present spawning populations include 5,000 fall King salmon, 2,000 Coho salmon, and 10,000 steelhead trout.

The topography of the Redwood Creek Basin limits possible storage sites to the main stem and to Prairie Creek. Because of its short length and its proximity to Highway 101, Prairie Creek was excluded from consideration.

Four storage sites on Redwood Creek were considered in this study, in addition to Green Point damsite, which was mentioned in Bulletin No. 3. They are all located in the reach of stream suitable for fisheries enhancement projects. Above this reach, the stream becomes too steep for the development of economical storage. Below the reach, the blockage of natural spawning area and lessening of enhancable stream length becomes critical.

Preliminary estimates of ideal enhancement flows are that an average of 43,000 acre-feet per year should be released from the proposed project. A rough evaluation of the sites considered showed that the unit cost of yield generally increased as the site was moved upstream.

It was concluded from this study that Lupton Dam and Reservoir would be the most favorable project. There is some question about the geological suitability of this site, but the location of the axis is not critical. It should be possible to find a suitable foundation for the height of dam considered.

Little River. The U. S. Fish and Wildlife Service reports that Little River is accessible to salmon for about 8 miles, and that log jams in the upper reaches hinder steelhead migrations. Although only small numbers of King salmon spawn in Little River, the stream is important for Coho salmon spawning. The spawning areas which are in the middle reaches of the stream are sufficient to support over 2,400 pairs of King salmon, or 9,000 pairs each of Coho salmon or steelhead trout.

The only two large storage sites on the Little River are Crannell and Tiptop. Crannel Reservoir was mentioned in Bulletin No. 3 as a possible source of domestic and irrigation water for the Eureka Plains area. It was estimated that 70,000 acre-feet of water could be supplied by the project for about $4.00 per acre-foot. Crannell Reservoir would block most of the spawning area in the basin, so it was not given serious consideration as a potential fisheries enhancement project.

Tiptop Reservoir would be capable of providing from 20,000 to 50,000 acre-feet of new yield at less than $4.00 per acre-foot. The ideal annual enhancement flow was estimated at 6,000 acre-feet.

Tiptop Reservoir is superior to Crannell Reservoir for fisheries enhancement, both from the standpoints of unit cost of yield and length of stream enhanced. However, Tiptop Dam would block fish from several important tributaries, so it is questionable whether the project would enhance the fisheries. The decision is dependent on biological considerations.

Bear River. The Bear River Basin is located between the drainage areas of the Eel and Mattole Rivers. With a total drainage area of 118 square miles, it is among the smaller coastal basins. The headwaters of the Bear River are 25-stream miles from the sea at an elevation of about

2,000 feet. The basin is rather narrow with numerous small tributaries. Because these tributaries are very steep, the only possible sites for economical storage are located on the main stem.

The Brushy Creek damsite on the upper Bear River was mentioned in Bulletin No. 3 as a possible fish enhancement and recreation project. It is located 0.4 mile above the mouth of Brushy Creek, about 22 miles from the ocean. The drainage area above the Brushy Creek site is 13.6 square miles, or about 11.5 percent of the basin area. The mean annual runoff at the site is estimated to be 43,000 acre-feet from area-precipitation comparison with the Mattole River.

No detailed work on the cost estimate of Brushy Creek Dam was done for the Bulletin No. 3 studies. The site was visited once, and the estimate was based on the 1:62,500 quad sheet in a manner similar to the methods used in the current study. Since that work was done, a more recent map has been published, and the new contours vary over 100 feet from the old ones. Accordingly, the current work does not agree with the data contained in Bulletin No. 3.

It was determined that a firm yield of around 15,000 acre-feet per year could be obtained at the Brushy Creek site at a unit cost of about $13 per acre-foot. The biologist estimated an "ideal flow range" for the Bear River of about 15,000 acre-feet per year, which slightly exceeds the economical potential of the Brushy Creek site. However, there is no downstream site at which a larger yield could be obtained at a comparable cost, due to the steepness of the stream below Brushy Creek. Therefore, it is concluded that the Brushy Creek damsite would be the most desirable location for a fish enhancement project in the upper Bear River Basin.

Mattole River. King salmon ascend the Mattole River to the vicinity of Thorn, about 60 river miles above the mouth. Coho salmon and steelhead trout are able to migrate several miles beyond the log jams and restricted channel which block the king salmon. Important tributaries for spawning include Honeydew and Bear Creeks. Average fish runs presently number about 5,000 King salmon, 2,000 Coho salmon, and 12,000 steelhead. Usable gravel in the Mattole drainage could provide spawning habitat for "7,900 pairs of king salmon" and "not more than 10,000 pairs of Coho salmon and a comparable number of steelhead trout".*

Because spawning activity is distributed throughout the Mattole River system, any reservoir providing fish enhancement flows should be located as near as possible to the headwaters, to avoid blocking of existing spawning grounds. This eliminates some economically attractive possibilities for mainstem storage in the canyon above Honeydew. Generally speaking, the tributary streams do not provide desirable storage sites.

Two damsites were investigated in this study, both in the upper reaches of the river system. Jewett damsite is located on Bear Creek, about one mile above its confluence with the Mattole River and about 47 river miles from the ocean. This site is topographically suited for a large amount of storage, but does not have a matching water supply. It is estimated that a reservoir at this site could supply 31,000 acre-feet annually at a unit cost of about $5.00 per acre-foot.

Thorn Reservoir, on the main stem Mattole River, was mentioned in Bulletin No. 3 as a possible development for fish enhancement and recreation. The dam axis for the study was located about 0.3 mile above

* "Natural Resources of Northwestern California - Report Appendix - A Preliminary Survey of Fish and Wildlife", U. S. Fish and Wildlife Service, 1960.

the mouth of Baker Creek. The present study used an axis 0.15 mile below Baker Creek, as recommended by Mr. Jack Wulff in a memorandum to Mr. M. Thiebaud in March 1956. Thorn Dam would thus be about 5 miles from the headwaters and some 61 river miles from the ocean.

Bulletin No. 3 spoke of a 35,000 acre-foot reservoir at Thorn, with an annual yield of 33,000 acre-feet. Estimates made for this study indicate that optimum sizing for Thorn Reservoir would be about 24,000 acre-feet. Such a reservoir would yield about 20,000 acre-feet on a fisheries enhancement schedule at a unit cost of around $16.00 per acre-foot.

The biologist's preliminary estimate of a desirable fish enhancement yield for the Mattole River is 50,000 acre-feet per year. It is concluded that such a yield could not be economically developed except by a main-stem reservoir. A dam and reservoir below Thorn Junction (mile 55) could probably develop 50,000 acre-feet of yield at a reasonable unit cost, but would inundate the settlement of Thorn.

Since Thorn and Jewett Reservoirs would have similar yields and costs, and Thorn Reservoir would enhance a 14 additional miles of stream, it is concluded that the Thorn site represents the most logical development in the upper Mattole Basin for the purpose of fish enhancement. It remains to be seen if the benefits to the fishery from the relatively small yield of Thorn Reservoir would justify the cost of the project.

Ten Mile River. The drainage system is made up of three main forks of similar size. The headwaters of each fork are 20 to 22 miles from the ocean and from 1,500 to 2,000 feet in elevation. The North and Middle Forks combine at a point 7 miles from the sea to form the main stem, while the South Fork enters the main stem only 2 miles from the ocean. Because of this configuration, any fishery enhancement project would benefit only one of the forks.

Bulletin No. 3 suggested construction of a dam in the lower reaches of the South Fork in conjunction with a dam on Pudding Creek. The two dams would form a single reservoir on the drainage divide, and would be used to supply irrigation water to the Fort Bragg area. Such a project would block almost the entire South Fork to spawning and thus was not considered as a possible fish enhancement project in this study.

The biologists estimate an "ideal flow" below a Ten Mile River fish enhancement project would require an annual yield of about 26,000 acre-feet. This seems high when compared to the estimates for other streams. At any rate, four damsites were selected for brief evaluation in the current study.

1. North Fork Ten Mile damsite -- on the North Fork, about 16 miles from the ocean. This site was investigated briefly in the studies for Bulletin No. 3.

2. Booth damsite -- on the Middle Fork, about 0.4 miles below Booth Gulch and also about 16 miles above the mouth. This is a "new" site.

3. Dutchman damsite -- on the South Fork, about 0.4 miles below Redwood Creek and 14 miles from the sea. This is also a "new" site.

4. Churchman damsite -- on the South Fork, about 0.4 miles below the mouth of Churchman Creek and 9 miles from the ocean. This site was also identified during the Bulletin No. 3 studies.

Each of the first three damsites has a drainage area of about 15 square miles and an estimated mean annual runoff of about 23,000 acre-feet. It was found that none of them would be capable of supplying yield at a reasonable cost. The optimum yield from the North Fork damsite is less than 5,000 acre-feet per year and probably would cost at least $15 per acre-foot. Yield from Booth and Dutchman Reservoirs would be even more costly.

Churchman damsite has a drainage area of 24 square miles, and an estimated mean annual runoff of 35,000 acre-feet. However, it is estimated that yield from this site would cost $20 per acre-foot for a yield of about 26,000 acre-feet. Because its yield would serve only 10 miles of stream, a reservoir at the Churchman site would probably not be economical.

It is concluded that the Ten Mile River is an unfavorable stream for a fishery enhancement project due to topographic limitations. The topographically suitable dam and reservoir sites are either so far up in the drainage area that the water supply is too small, or they are too near the mouth of the river to be of much use to the fish.

Noyo River. The Noyo River Basin is generally lower than the adjoining basins; its uppermost headwater are barely above the 1,000-foot elevation. Although no specific information on the existing Noyo fishery is available, it is probable that the moderate stream gradients permit salmon and steelhead to range far into the upper reaches. Therefore, it is unlikely that any developments in the lower reaches would be acceptable from the standpoint of fishery enhancement.

The main stem of the Noyo River extends almost due eastward from the ocean for a distance of about 31 miles as measured along the stream. For most of this length, the Fort Bragg-Willits railroad track parallels the river. This is the track of the famous little train affectionately known as the "Skunk", a popular tourist attraction. It is felt that the expense and public relations problems which would be associated with relocation of this railroad are sufficient justification for not considering any damsites on the main stem of the river.

The South Fork of the Noyo River joins the main stem about 6 miles from the ocean. This fork constitutes a relatively good site for a moderate amount of storage, but there are no damsites on the fork which would permit the economic development of yields consistent with the rather meager water supply. A quick analysis of Brandon damsite, 0.65 miles below the mouth of the North Fork of the South Fork, showed that a yield of 7,000 acre-feet per year could be obtained at a cost of about $11 per acre-foot. (The 7,000 acre-foot yield corresponds to the biologist's preliminary estimate of a desirable fishery enhancement yield.) However, because releases from a dam on the South Fork would enhance only 10 miles of stream, it was concluded that the North Fork projects discussed below are superior.

The only other possibilities for storage on tributaries of the Noyo River are found on the North Fork Noyo which joins the main stem at mile 22.5. Two damsites on the North Fork were evaluated:

Northspur:	0.25 miles above the mouth
Hayworth No. 3:	0.3 miles above Marble Gulch

Three damsites with the Hayworth name were considered for Bulletin No. 3, and one was suggested in that report as a possible fish enhancement and recreation project. This site was known as Hayworth No. 2 and is located about 2 miles above the Hayworth No. 3 site. However, subsequent studies indicated that the Hayworth No. 3 damsite is the most desirable of the three. Because the No. 3 reservoir area also appears topographically superior, it was selected for evaluation in the present study. A rough cost estimate concluded that a reservoir at this site could supply a yield of 7,000 acre-feet per year at a unit cost of about $12 per acre-foot. The cheapest water from this site could be obtained at a cost of about $10.00 per acre-foot with a yield of 4,500 acre-feet. Yield from Mayworth No. 3 would enhance a total of about 24 miles of stream.

About 1 mile below Hayworth No. 3 damsite lies an apparently superior site named Northspur. It is estimated that 7,000 acre-feet of annual yield, on a fisheries enhancement schedule, could be obtained from Northspur Reservoir at a unit cost of about $7.00 per acre-foot. On the basis of map evaluation, Northspur seems the most likely site for a fishery enhancement project in the Noyo River system.

Big River. The lower reaches of Big River are relatively flat and broad, with a mean gradient of about 6 feet per mile. About 27 stream-miles above the ocean, the North and South Forks join the main stem. Each of the three portions of the upper drainage area are of approximately equal size. The headwaters of the North Fork and the main stem are about 40 stream-miles from the mouth, and the South Fork extends about 48 miles. Since the upper reaches of these three tributaries are probably useful as steelhead spawning areas, any reservoir to enhance the fishery should be located on one of the tributaries. Accordingly, one damsite on each of the three streams was evaluated in an attempt to identify the most favorable means of developing the 14,000 acre-foot annual yield recommended by the biologists.

North Fork. A site located about 0.35 miles above the mouth of the East Branch of the North Fork was selected by map inspection. This site was named "Dunlap Damsite" after a lumbering community within the reservoir area. The drainage area at this site is 33.2 square miles, and the mean annual runoff was estimated to be 45,500 acre-feet. Total length of stream enhanced would be about 36 miles. It was estimated that a yield of 8,000 acre-feet per year could be developed at a unit cost of around $6.00 per acre-foot, while a yield of 14,000 acre-feet would cost from $8.00 to

$9.00 per acre-foot. These costs could be considerably higher, depending on the state of development of the community of Dunlap.

Upper Main Stem. A site on this stream, known as Russell damsite, was identified as a part of the early Bulletin No. 3 studies, but apparently was abandoned after a field reconnaissance. A map examination of the site showed that the amount of storage available would not justify the size of dam required. Consequently, yield from this site on the upper main stem would be considerably more expensive than that from alternate sites on the North and South Forks. No other likely sites exist on the upper main stem.

South Fork. Hellgate damsite on the South Fork Big River was evaluated for the Bulletin No. 3 studies. However, it was not mentioned in the report as a possible fishery enhancement project. The damsite is located in the Northwest 1/2, Southwest 1/4, Section 13, Township 16 North, Range 15 West, at a point 8 miles above the mouth of the South Fork and 36.5 miles from the ocean. The drainage area at this site is 38.4 square miles, and the mean annual runoff was estimated as 52,600 acre-feet. The estimated cost of yield from Hellgate Reservoir was estimated to be about $14.00 per acre-foot for yields between 14,000 and 30,000 acre-feet per year. Map inspection revealed no other sites on the South Fork which appear superior to Hellgate.

Conclusions

1. A fishery enhancement dam in the Big River System should be located on one of the three main upper tributaries.

2. No reasonable sites exist on the upper main stem.

3. Dunlap damsite on the North Fork appears to offer the best possibility for fish enhancement from a cost standpoint. An evaluation of cost of purchasing the reservoir area could change the picture.

4. Hellgate damsite on the South Fork should be considered only if Dunlap Dam is not feasible, or if yields in excess of 25,000 acre-feet per year are required.

Albion River. The Albion River Basin is one of the smallest included in this study. Its headwaters are about 18 miles from the sea at an elevation of about 800 feet. The South Fork joins the main stem at Mile 8; the mouth of the North Fork is near Mile 13. The biologists' preliminary estimate of "ideal flow" below a fishery enhancement dam on the Albion River would require an annual yield of about 2,200 acre-feet.

Bulletin No. 3 identified a possible reservoir site on the main stem just below the mouth of the South Fork. This was "MacDonald Reservoir" and it was intended to provide an irrigation yield of 15,000 acre-feet to the adjacent coastal plain. Because of its location, MacDonald Reservoir was not considered as a possible fishery enhancement project.

The available maps of the Albion River area have a contour interval of 100 feet and therefore are not adequate for even a preliminary estimate of a project of the small size needed to furnish the required yield. However, the following conclusions were drawn from a map reconnaissance:

1. Storage on the upper main stem of the Albion River is not practical because the community of Comptche is within the area which would be inundated by such a project.

2. Possible storage sites exist on both the North and South Forks. Very rough estimates show that sufficient yield could be obtained from these sites, but it would be relatively costly.

3. The Albion River presents less attractive possibilities for a fishery enhancement project than many of the other coastal streams.

Navarro River. The Navarro River System is among the most complicated of those included in the present study. At least six important tributaries combine to form the main Navarro River. The system supports a good steelhead trout population, but this resource could be increased by maintaining summer flows in the various headwaters. A discussion of the major tributaries and of possible reservoir sites is presented below.

North Fork Navarro River. The North Fork Navarro River joins the main stem at a point about 7 river-miles from the ocean. About 6 miles farther upstream, the two branches of the North Fork combine.

The headwaters of the North Branch are about 23 miles from the sea, at an elevation around 1,000 feet. One damsite on the North Branch was identified during the Bulletin No. 3 studies. It is the "Dutch Henry" site, located about 5 miles above the mouth of the North Branch, and 18 miles from the sea. The Dutch Henry site was not mentioned in the report. Although it appears to be a fairly good site, it was not evaluated for the current study since its waters would serve only a small length of stream.

The South Branch of the North Fork Navarro River begins near the 3,000-foot level, about 28 miles from the sea. The most desirable damsite on this branch appears to be the "Castle Garden" site recommended in Bulletin No. 3. It is located 8 miles up the South Branch, 21 miles from the sea. A rough evaluation was made of the Castle Garden site, and it was found that an optimum yield of 12,000 acre-feet would cost nearly $25 per acre-foot. Because of this high cost and the limited length of stream served, it was concluded that the South Branch is an unfavorable location for a fishery enhancement project.

Mill Creek. Mill Creek joins the main stem of the Navarro River from the north at Mile 22.6 It is the smallest of the main tributaries and is not topographically desirable as a dam or reservoir location.

Indian Creek. Indian Creek drains considerable area northeast of Anderson Valley and joins the main stem of the Navarro River at Mile 28.2. Its total length is about 12 miles and the upper reaches are relatively steep. Lone Tree damsite, 6 miles above the mouth, was advanced as a possible fishery enhancement project in Bulletin No. 3. An evaluation of this site showed that the yield would cost over $20 per acre-foot, in amounts up to about 25,000 acre-feet per year. It seems unlikely that fish enhancement benefits would justify such expensive yield.

Anderson Creek. Anderson Creek joins the main stem at Mile 28.5. It has a total length of about 14 miles, 8 miles of which are within Anderson Valley. There are no particularly attractive damsites on Anderson Creek. Two were inspected during the Bulletin No. 3 studies, but no further work was done on them.

Rancheria Creek. The main channel of the Navarro is known as "Rancheria Creek" above the mouth of Anderson Creek. It has a total length of about 34 miles, with its headwaters some 62 miles from the ocean. Because of its length, Rancheria Creek is the logical location for a fishery enhancement project.

Upper Rancheria Creek was rather thoroughly searched for damsites during thr Bulletin No. 3 studies. At least six sites were inspected in the field, and one, Big Foot damsite, was mentioned in Bulletin No. 3 as a possible fishery enhancement project. Big Foot damsite was evaluated for the current study, and a second site, about 11 miles downstream, was evaluated as a possible alternative.

The analysis of Big Foot Reservoir agreed with the Bulletin No. 3 data; a yield of 5,000 to 7,000 acre-feet per year could be furnished at a unit cost of around $10 per acre-foot.

Because of the rather small yield available at the Big Foot site, Rector damsite was chosen by map inspection as a representative downstream site. A rough evaluation of Rector Reservoir showed that the unit cost of yield would be about the same as that from Big Foot Reservoir, but that 10,000 to 20,000 acre-feet of yield could be obtained.

Several possible damsites exist between Big Foot and Rector damsites. It is likely that yield at most of these sites could be obtained for about $10 per acre-foot, in amounts roughly proportional to the drainage areas. Therefore, the location of a reservoir on Rancheria Creek requires a knowledge of the benefits resulting from various yields, keeping in mind that an increase in yield would result in a decrease in the amount of stream served due to the necessity of moving the dam downstream.

Conclusions

1. Yield from reservoirs on the North and South Branches of the North Fork would be very expensive and of limited usefulness. Castle Garden damsite is perhaps the best within this portion of the drainage area, but its high cost is unlikely to be warranted.

2. Lone Tree damsite on Indian Creek is the best looking site on that tributary. However, it is also expensive and not very effective.

3. Both Mill Creek and Anderson Creek are barren of attractive damsites.

4. Upper Rancheria Creek is the logical location for a fishery enhancement dam, inasmuch as the maximum length of stream would be

served, and the unit cost of water would be much lower than that from sites on other tributaries.

5. Since many sites exist on upper Rancheria Creek, a selection must be based on a knowledge of the fishery benefits associated with various yields.

Garcia River. The Garcia River is typical of the smaller coastal streams. It flows irregularly westward for a distance of some 40 miles. Its headwaters are about 1,500 feet above sea level. There are no major tributaries except the North Fork Garcia River which joins the main stem about 9 miles from the ocean.

Only one sizable storage site is evident on the main stem. This is the "Garcia Reservoir site," which was mentioned in Bulletin No. 3 as a possible fish and recreation project. This site adheres closely to the classic conception of headwater storage for streamflow maintenance. Its drainage area of 16 square miles is about 15 percent of the total basin area, and its location at Mile 35 is within 6 miles of the headwaters, so that a maximum length of stream could be served.

Garcia damsite is located in the narrow canyon below the junction of Mill and Pardaloe Creeks. The damsite and reservoir were mapped for the Bulletin No. 3 studies, and the site was reported to be suitable for an earthfill dam. Bulletin No. 3 proposed a reservoir with 15,000 acre-feet of storage and a yield of 9,200 acre-feet per year. A rough evaluation of the site for the current study indicated that an optimum yield of about 9,500 acre-feet could be furnished at a unit cost of around $13 per acre-foot. However, the storage required for this yield was estimated to be only 7,500 acre-feet. The difference between the current estimate and that of Bulletin No. 3 is due to (1) a difference in runoff estimates, and (2) a different method of determining the storage-yield relationship. The current estimate of water supply is based on an area-precipitation relationship with the South Fork Gualala River near Annapolis, which resulted in a mean annual runoff of 28,600 acre-feet. The Bulletin No. 3 estimate of mean annual runoff was 22,000 acre-feet.

In conclusion, the Garcia damsite represents probably the best site within the Garcia River system for developing a yield of around 9,000 acre-feet per year. The biologists estimated an "ideal" flow of only 6,000 acre-feet per year, but the sites upstream from the Garcia site would not supply such a yield because of the branching of the river just upstream.

Gualala River. The drainage pattern of the Gualala River system is rather complex in comparison to the other coastal streams. The major tributaries of the Gualala River are the North, South, and Wheatfield Forks. The North and South Forks join about 3 miles from the ocean, and the Wheatfield Fork meets the South Fork about 8 miles above that junction. Other tributaries of the South Fork include Buckeye and Rockpile Creeks.

Three dams, one on each major fork, were mentioned in Bulletin No. 3 as possible fish and recreation projects. Several other damsites were investigated during the Bulletin No. 3 studies, but most were found to be geologically undesirable. The three sites on the main forks were re-evaluated for the current study using more recent runoff and yield data.

North Fork. The total length of the North Fork Gualala River is about 20 miles. Billings damsite is located about 12.5 miles above the mouth. Its drainage area is 16.6 square miles, and the mean annual runoff at the site was estimated as 34,600 acre-feet. The site is the only one in the Gualala Basin which was mapped for the Bulletin No. 3 studies.

An evaluation of the Billings site for the current study indicated that an optimum size reservoir would develop from 13,000 to 17,000 acre-feet of yield (on a fish release schedule) at a unit cost of about $11 per acre-foot. The biologists estimated a yield of about 15,000 acre-feet per year would provide "ideal flow" conditions below a fishery enhancement reservoir in the Gualala Basin. Such a yield from Billings Reservoir would result in an annual cost per mile of stream enhanced of over $10,000. It is unlikely that such a cost could be justified by the resultant benefits.

South Fork. The headwaters of the South Fork Gualala River are about 39 miles from the sea, at an elevation of 1,500 feet. Houser Bridge damsite, at Mile 24.7, was selected for presentation in Bulletin No. 3. Its drainage area is 34 square miles, and the mean annual runoff was estimated as 64,000 acre-feet.

The unit cost of yield from Houser Bridge Reservoir was estimated as $11 per acre-foot, or about the same as the yield from Billings Reservoir. However, the optimum amount of yield would be in the range of 21,000 to 33,000 acre-feet per year. If the project were sized to yield only 15,000 acre-feet, the unit cost would increase to around $13. With such a sizing, the annual cost would amount to about $8,000 per mile of stream enhanced (including the main stem). This is significantly lower than the similar cost for Billings Reservoir.

Wheatfield Fork. Total length of the Wheatfield Fork is about 30 miles. Neese Ridge damsite, 19.5 miles above the junction and 30.5 miles from the sea, was selected as the best site on this fork for Bulletin No. 3. The mean annual runoff from the 26 square mile drainage area was estimated to be 50,000 acre-feet.

A yield of 15,000 acre-feet was found to be near optimum sizing for Neese Ridge Reservoir, and the unit cost of that yield was estimated as $10 per acre-foot. The resulting annual cost per mile of stream enhanced is about $5,400, which is more in keeping with results on other streams studied.

Of the three Gualala River damsites proposed in Bulletin No. 3, the Neese Ridge site seems the most worthy of further consideration. This conclusion, however, does not consider the differences in fish benefits which would occur below different dams.

The current study was based mainly on the idea of identifying the most attractive <u>single</u> project within the basin. For many of the streams studied, this is a reasonable approach; but due to its complexity, it is felt that the Gualala Basin requires a more comprehensive approach. An evaluation of a combination of smaller headwaters projects should be made.

TABLE 13

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency
Smith River	Adams	Smith River	26	17N	1E	500	25	1,000	1954	DWR					
Smith River	Big Slide	Rowdy Creek	16	18N	1E	200	20	400	1952	DWR					
Smith River	Canthook	S. F. Smith River	10	15N	2E	200	20	1,100	1952	DWR					
Smith River	Idlewild	M. F. Smith River	1	17N	3E	200	20	1,360	1952	DWR					
Smith River	Jones Creek	M. F. Smith River	16	17N	3E	200	20	1,200	1952	DWR					
Smith River	Rowdy	Rowdy Creek	30	18N	1E	200	10&20	340	1952	DWR					
Smith River	Still Creek	Still Creek	18	18N	2W	200	20	1,360	1952	DWR					
Smith River	Washington Flat	M. F. Smith River	1	17N	3E	200	20	1,380	1952	DWR					
Klamath River	Copco	Klamath River	29	48N	4W	500	20	2,800	1954	DWR					
Klamath River	Hamburg	Klamath River	31	46N	10W	200	20	1,900	1954	DWR					
Klamath River	Happy Camp	Klamath River	33	16N	7E	100	20	1,600	1954	DWR					
Klamath River	Hornbrook	Klamath River	5	47N	6W	500	20	2,600	1954	DWR					
Klamath River	Humboldt	Klamath River	10	12N	2E	200	20	460	1954	DWR					
Klamath River	Irongate	Klamath River	9	47N	5W	500	20	2,460	1956						
Klamath River	Irongate	Klamath River	9	47N	5W	50	5	2,450		Calif.-Ore. Power Co.					
Klamath River	Jenny	Klamath River	36	48N	5W	500	20	3,000	1954	DWR					
Klamath River	Riverview	Klamath River	14	46N	7W	500	20	2,700	1955	DWR					
Klamath River	Slate Creek	Klamath River	19	10N	5E	500	25	1,100	1954	DWR					
Klamath River	Somes Mountain	Klamath River	16	11N	6E	500	25	1,100	1955	DWR					
Klamath River	Wilson	Klamath River	5	15N	6E	200	20	1,600	1954	DWR					
Klamath River	Boundary	Lost River	18	48N	7E	50	5	4,235	1946	USBR					
Salmon River	Black Bear	S. F. Salmon River	33	39N	12W	500	20	assumed datum	1954	DWR					
Salmon River	Boulder	N. F. Salmon River	27	40N	12W	500	20	2,200	1954	DWR					
Salmon River	King Solomon	S. F. Salmon River		38N	12W	500	20	1,500	1954	DWR					
Salmon River	Kismet	N. F. Salmon River	27	40N	11W	500	20	3,000	1954	DWR					
Salmon River	Morehouse	Salmon River	21	11N	7E	525	20	1,600	1954	DWR					
Scott River	Callahan	Scott River	17	40N	8W	500	20	3,400	1953	DWR	500	20	3,400	1953	DWR
Scott River	Etna	French Creek	15	41N	9W	200	10	3,000	1955	DWR					
Scott River	Grouse Ridge	Moffett Creek	18	43N	7W	500	20	3,700	1954	DWR					
Scott River	Moffett Creek	Moffett Creek	12	43N	8W	500	20	3,600	1953	DWR	500	20	3,600	1953	DWR

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency
Scott River	Mugginsville	Mill Creek	14	43N	10W		20		1957	DWR					
Scott River	Scott Valley	Scott River				200	10	2,850		DWR					
Scott River	Spring Flat	Scott River	28	44N	11W	500	20	3,100	1955	DWR					
Shasta River	Grenada Ranch	Shasta River	36	44N	6W	100	5	2,775	1958	DWR	400	10	2,600	1958	DWR
Shasta River	Montague, Lower	Shasta River	6	45N	6W	200	10	2,540	1953	DWR					
Shasta River	Montague, Upper	Shasta River	7	45N	6W	200	10	2,500	1953	DWR					
Shasta River	Montague	Shasta River	7	45N	6W	100	5	2,500	1958	DWR	400	10	2,520	1958	DWR
Shasta River	Table Rock, Lower	Little Shasta River	20	45N	4W	200	10	2,940	1953	DWR					
Trinity River	Beaver	Trinity River	2	8N	4E	500	20	1,500	1955	DWR					
Trinity River	Big Bar	Trinity River	4	4N	8E	400	20	2,000	1960	DWR	400	20	2,000	1960	DWR
Trinity River	Burnt Ranch	Trinity River	13	5N	6E	400	20	1,400	1960	DWR	400	20	1,340	1960	DWR
Trinity River	Burnt Ranch	Trinity River	13	5N	6E	200	20	1,660	1954	DWR					
Trinity River	Burnt Ranch	Trinity River	13	5N	6E	50	20	1,400	1956	DWR					
Trinity River	Burnt Ranch	Trinity River	13	5N	6E	100	20	1,220		DWR					
Trinity River	Helena	Trinity River	36	34N	12W	400	20	2,000	1960	DWR	400	20	2,000	1960	DWR
Trinity River	Helena, Lower	Trinity River	36	34N	12W	200	10&100	2,500							
Trinity River	Helena, Lower	Trinity River	36	34N	12W	400	50	2,500		DWR					
Trinity River	Helena, Lower	Trinity River	36	34N	12W	100	10	1,800		DWR					
Trinity River	Helena, Lower	Trinity River	36	34N	12W	1,320	50	2,250	1954	DWR					
Trinity River	Horse Linto, Lower	Trinity River	5	7N	5E	800	40	1,400	1964	DWR					
Trinity River	Ironside	Trinity River	35	6N	6E		10	1,220							
Trinity River	Lowden	Trinity River	28	33N	9W	400	20	2,000	1960	DWR	400	20	2,000	1960	DWR
Trinity River	Lowden	Trinity River	28	33N	9W	200	10	1,950	1958	DWR					
Trinity River	Eltapom	S. F. Trinity River	10	3N	6E	500	20	1,700	1954	DWR					
Trinity River	Eltapom	S. F. Trinity River	10	3N	6E	400	20	2,000	1961	DWR					
Trinity River	Grel	S. F. Trinity River	1	2N	6E	200	100	1,700	1958	DWR					
Trinity River	Grouse Creek	S. F. Trinity River	7	4N	6E	200	20	1,300	1958	DWR					
Trinity River	Hyampom	S. F. Trinity River	10	3N	6E	100	25	1,400	1958	DWR					
Trinity River	Layman	Hayfork Creek	15	31N	11W	400	20	2,700	1958	DWR					
Mad River	Blue Lake	Mad River	8	5N	2E	500	20	500		DWR					

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency
Mad River	Butler Valley	Mad River	31	4N	3E	500	20	700	1957	DWR					
Mad River	Butler Valley	Mad River	31	4N	3E	200	20	480	1955	DWR	1,000	40	440	1955	DWR
Mad River	Canyon Creek	Mad River	16	5N	2E	200	10	350	1931	USCE					
Mad River	Lentell	Mad River	11	2S	7E	500	20	2,900	1951	DWR	500	20	2,800	1951	DWR
Mad River	Olsen	Mad River	34	1N	6E	500	20	2,700	1951	DWR	500	20	2,700	1951	DWR
Mad River	Ranger Station	Mad River	17	1N	6E	500	20	2,700	1955	DWR					
Mad River	Ranger Station	Mad River	17	1N	6E	200	20	2,700	1956	DWR					
Mad River	Ruth	Mad River	19	1S	7E	500	20	2,900	1951	DWR	500	20	2,800	1951	DWR
Mad River	Sweasey	Mad River	16	5N	2E	500	50	500	1956	DWR					
Van Duzen River	Camp	Van Duzen River	4	1N	5E	200	20	2,800		DWR					
Van Duzen River	Dinsmore	Van Duzen River	5	1N	5E	500	20	2,640	1952	DWR	500	20	2,640	1952	DWR
Van Duzen River	Eaton	Van Duzen River	5	1N	5E	200	20	2,800	1954	DWR					
Van Duzen River	Eaton	Van Duzen River	5	1N	5E	500	20	2,800		DWR					
Van Duzen River	Grizzly	Van Duzen River	11	1N	2E	200	20	800	1954	DWR					
Van Duzen River	Larabee Valley	S. F. Van Duzen River	19	1N	5E	200	20	2,480	1955	DWR	1,000	40	2,480	1955	DWR
Van Duzen River	Lassic Creek	Van Duzen River	22	1S	6E	500	20	3,000	1952	DWR	500	20	3,000	1952	DWR
Van Duzen River	Yager Creek	Yager Creek	6	2N	2E	200	20	640	1955	DWR	1,000	40	680	1955	DWR
Eel River	Bell Springs	M. F. Eel River	30	24N	14W	500	25	1,500	1954	DWR					
Eel River	Benmore	S. F. Eel River	13	18N	11W	200	5	2,075	1958	DWR					
Eel River	Branscomb	S. F. Eel River	4	21N	16W	100	5	1,870	1959	DWR					
Eel River	Caution	N. F. Eel River	31	4S	8E	200	20	1,900		DWR					
Eel River	Dos Rios	M. F. Eel River	4	21N	13W	400	20	1,740	1960	DWR	400	20	1,740	1960	DWR
Eel River	Dos Rios	M. F. Eel River	4	21N	13W	100	20	1,740	1960	DWR					
Eel River	English Ridge	Eel River	6	19N	12W	400	20	1,760	1962	DWR	400	20	1,760	1962	DWR
Eel River	Etsel, Lower	M. F. Eel River	24	22N	12W	500	20	1,800	1951	DWR					
Eel River	Etsel, Lower	M. F. Eel River	24	22N	12W	400	20	1,700	1960	DWR	400	20	1,700	1960	DWR
Eel River	Etsel, Upper	M. F. Eel River	1	22N	12W	500	20	1,780	1951	DWR					
Eel River	Etsel, Upper	M. F. Eel River	1	22N	12W	200	20	1,720	1951	DWR					
Eel River	Etsel, Upper (Spencer)	M. F. Eel River	1	22N	12W	400	20	1,700	1959	DWR	400	20	1,700	1960	DWR

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top Contour	Date	Agency
Eel River	Etsel, Upper	M. F. Eel River	1	22N	12W	200	5		1958	DWR					
Eel River	Franciscan	Short Creek	28	23N	12W	400	20	1,700	1960	DWR	400	20	1,700	1960	DWR
Eel River	Garcey	Eel River	22	19N	12W	400	20	1,760	1962	DWR	400	20	1,760	1962	DWR
Eel River	Hearst, Lower	Eel River	7	19N	12W	500	20	1,700	1951	DWR					
Eel River	Hearst, Upper	Eel River	8	19N	12W	500	20	1,700	1951	DWR	500	20	1,640	1951	DWR
Eel River	Hearst, Upper	Eel River	8	19N	12W	200	20	1,600	1951	DWR					
Eel River	Hulls Valley	Hulls Creek	25	24N	13W	200	20	2,820	1955	DWR					
Eel River	Jarbow	M. F. Eel River	4	21N	12W	400	20	1,740	1960	DWR	400	20	1,740	1960	DWR
Eel River	Jarbow	M. F. Eel River	4	21N	12W	1,000	20	1,500	1950	Hammond, Jensen & Whalen	1,000	20	1,500	1950	Hammond, Jensen & Whalen
Eel River	Jarbow	M. F. Eel River	4	21N	12W	100	20	1,740	1960	DWR					
Eel River	Lake Pillsbury (Enlarged)	Eel River	23	18N	10W	400	10	2,150	1958	DWR	400	10	2,150	1958	DWR
Eel River	Marshall	Eel River	1	18N	12W	400	10	1,650	1958	DWR	400	10	1,650	1958	DWR
Eel River	Marshall	Eel River	1	18N	12W	400	20	1,760	1962	DWR	400	20	1,760	1962	DWR
Eel River	Mina	N. F. Eel River	12	8S	7E	200	10&50	1,420							
Eel River	Red Mountain	N. F. Eel River	31	4S	8E	200	5	1,860	1932	USCE					
Eel River	Red Mountain	N. F. Eel River	31	4S	8E	500	20	2,000		DWR	500	20	1,900	1951	DWR
Eel River	Sequoia	Eel River	6	2S	4E	500	20	800	1954	DWR					
Eel River	Sequoia	Eel River	6	2S	4E	200	20	800	1955	DWR					
Eel River	Streeter	Tenmile Creek	21	22N	15W	500	20	1,600	1955	DWR	500	20	1,525	1955	DWR
Eel River	Valleys End	Tomki Creek	17	18N	12W	500	20	1,780	1955	DWR	500	20	1,780	1955	DWR
Eel River	Williams Valley	Short Creek	23	23N	12W	500	20	1,700	1950	DWR	500	20	1,700	1955	DWR
Eel River	Willis Ridge	Eel River	32	21N	13W	500	25	2,100	1954	DWR					
Eel River	Willow Creek	Willow Creek	26	5S	6E	300	20	1,300	1954	DWR					
Eel River	Woodman	Eel River	14	22N	14N	300	20	1,500	1958	DWR					
Mattole River	Sterrett Hole	Mattole River	25	3S	1E	200	20	860	1954	DWR					
Mattole River	Thorne	Mattole River	22	5S	2E	200	20	1,200	1955	DWR	1,000	50	1,200	1955	DWR
Noyo River	Caspar	Caspar Creek	9	17N	17W		20	220	1955	DWR	1,000	20&50	220	1955	DWR
Noyo River	Hayworth	Noyo River	33	19N	15W	200	20	640	1955	DWR	1,000	50	600	1955	DWR
Navarro River	Big Foot	Rancheria Creek	30	12N	13W	200	10	1,070	1952	DWR	500	20	1,060	1952	DWR

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency
Navarro River	Castle Garden	N. F. Navarro River	19	15N	14W		20	640	1955	DWR	1,000	50	600	1955	DWR
Navarro River	Lone Tree	Indian Creek	14	14N	14W			960	1955	DWR	1,000	50	900	1955	DWR
Garcia River	Garcia River	Garcia River	12	12N	14W	500	20	1,080	1950	DWR	500	20	1,080	1950	DWR
Garcia River	Garcia River	Garcia River	12	12N	14W	200	20	1,080	1950	DWR	200	20	1,080	1950	DWR
Gualala River	Billings	Bear and Billings Creeks	34	12N	14W	500	10	260	1952	DWR	500	20	260	1952	DWR
Gualala River	Houser Bridge	Gualala River	22	9N	13W	200	10	470	1952	DWR					
Gualala River	Neese Ridge	Wheatfield Fork Gualala River	31	10N	12W	200	10	250	1952	DWR					
(Miscellaneous Coastal Streams)	Crannell	Little River	9	7N	1E	200	20	260	1955	DWR	1,000	20	260	1955	DWR
(Miscellaneous Coastal Streams)	Glenblair	Pudding Creek	3	18N	17W	200	20	260		DWR					
(Miscellaneous Coastal Streams)	Greenpoint, Upper	Redwood Creek	15	6N	3E	200	20	980	1955	DWR	1,000	40	960	1955	DWR
(Miscellaneous Coastal Streams)	Hellgate	Big River	13	16N	15W	200	20	560	1955	DWR	1,000	50	450	1955	DWR
(Miscellaneous Coastal Streams)	MacDonald (Mathison)	Albion River	17	16N	16W	200	20	200	1955	DWR	1,000	50	140	1955	DWR
(Miscellaneous Coastal Streams)	Orick	Redwood Creek	11	10N	1E	200	20	560	1954	DWR					
(Miscellaneous Coastal Streams)	Tin Can	Alder Creek	11	13N	16W	200	20	760	1955	DWR	1,000	50	750	1955	DWR
(Miscellaneous Coastal Stream)	Yesmar (Ramsey)	Ten Mile River	14	20N	17W	200	20	300		DWR					
(Miscellaneous Coastal Stream)	Glenblair-Ramsey	Pudding Creek Ten Mile River	3 14	18N 20N	17W 17W						1,000	50	250		DWR
Russian River	Ackerman Creek	Ackerman Creek	6	15N	12W	200	20	1,000	1955	DWR					
Russian River	Ackerman Creek	Ackerman Creek	6	15N	12W	500	20	1,000	1955	DWR	500	20	1,000		DWR
Russian River	Bearpen	Big Austin Creek	5	8N	11W	500	20	420	1950	DWR	500	20	420	1950	DWR
Russian River	Big Sulphur	Big Sulphur Creek	10	11N	10W	200	10	900	1950	DWR	1,000	25	800	1949	DWR
Russian River	Coyote Valley	E. F. Russian River	34	16N	12W	400	10	900	1950	USCE	1,000	25	900	1944	USCE
Russian River	Coyote Valley	E. F. Russian River	34	16N	12W	200	10&25	850							
Russian River	Cummisky	Cummisky Creek	10	11N	10W	500	20	620	1950	DWR	500	20	620	1950	DWR
Russian River	Dry Creek	Dry Creek	5	10N	11W	100	25	625	1955	DWR					

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top: Contour	Date	Agency
Russian River	Feliz	Feliz Creek	24	13N	12W	500	20	640	1950	DWR	500	20	640	1950	DWR
Russian River	Feliz	Feliz Creek	24	13N	12W	200	20	700	1955	DWR					
Russian River	Franz	Franz Creek	24	9N	8W	200	20	400		DWR					
Russian River	Franz	Franz Creek	24	9N	8W	440	20	400		DWR					
Russian River	Maacama Creek	Maacama Creek	9	9N	8W	100	5	450	1940	USCE					
Russian River	Maacama Creek	Maacama Creek	9	9N	8W	500	20	400		DWR	500	20	360		DWR
Russian River	Mark West	Mark West Creek	14	8N	8W	100	5	740	1945	USCE					
Russian River	Mark West	Mark West Creek	14	8N	8W	400	20	540		DWR	400	20	540		DWR
Russian River	Mill Creek	Mill Creek	25	9N	10W	500	20	400	1950	DWR	500	20	400	1950	DWR
Russian River	Robertson	Robertson Creek	7	14N	12W	500	20	960	1950	DWR	500	20	800	1950	DWR
Russian River	Robertson	Robertson Creek	7	14N	12W	200	20	960	1955	DWR					
Russian River	Saysal	Saysal Creek	25	10N	9W	400	20	500	1951	DWR	500	20	500	1951	DWR
Russian River	Warm Springs	Warm Springs Creek	24	10N	11E	500	20	460	1950	DWR	500	20	460	1950	DWR
Sacramento River	Mule Mountain	Clear Creek				500	20	1,260	1948	DWR	500	20	1,260	1948	DWR
Sacramento River	Towerhouse	Clear Creek				200	5&10		1956	USBR					
Sacramento River	Whiskeytown	Clear Creek				100	5	1,335	1956	USBR	200	5&10	1,600	1956	USBR
Sacramento River	Dippingvat Flat	S. F. Cottonwood Creek	36	27N	7W	200	20	1,300	1954	DWR					
Sacramento River	Fiddlers No. 2	M. F. Cottonwood Creek	28	29N	7W	100	5	835	1946	USBR	500	10	980	1946	USBR
Sacramento River	Hulen	N. F. Cottonwood Creek	16	30N	6W	500	10	850	1945	USBR					
Sacramento River	Black Butte	Stony Creek	29	23N	4W	200	5	525	1954	USCE					
Sacramento River	Newville	N. F. Stony Creek	3	22N	6W	200	20	940	1954	DWR					
Sacramento River	Newville	N. F. Stony Creek	3	22N	6W	400	20	1,100	1960	DWR	400	20	1,100	1960	DWR
Sacramento River	Newville	N. F. Stony Creek	3	22N	6W	1,000	20	1,100	1960	DWR	1,000	20	1,100	1960	DWR
Sacramento River	Rancheria (Upper Millsite)	Stony Creek	14	21N	6W	400	20	1,100	1960	DWR	400	20	1,100	1960	DWR
Sacramento River	Rancheria (Upper Millsite)	Stony Creek	14	21N	6W	1,000	20	1,100	1960	DWR	1,000	20	1,100	1960	DWR
Sacramento River	Paskenta	Thomes Creek	6	23N	7W	400	20	1,100	1960	DWR	400	20	1,100	1960	DWR
Sacramento River	Paskenta	Thomes Creek	6	23N	7W	50	5	1,000	1946	DWR					
Sacramento River	Paskenta	Thomes Creek	6	23N	7W	1,000	20	1,100	1960	DWR	1,000	20	1,100	1960	DWR

TABLE 13
(Continued)

SUMMARY OF AVAILABLE TOPOGRAPHIC MAPPING

River Drainage Basin	Dam and/or Reservoir site	Stream	Location			Damsite Map					Reservoir Area Map				
			Sec.	T.	R.	Scale (ft/in)	C.I. (ft)	Elev. Top Contour	Date	Agency	Scale (ft/in)	C.I. (ft)	Elev. Top Contour	Date	Agency
Sacramento River	Goodings	Maxwell Creek	19	9N	4W	1,000	25	625	1956	DWR					
Sacramento River	Jerusalem	Soda Creek	14	11N	6W	100	10	1,060	1955	USBR					
Sacramento River	Stienhart	Soda Creek	27	12N	6W	200	20	1,400	1955	DWR					
Sacramento River	Guenoc	Putah Creek	27	11N	6W	1,000	20	1,180	1946	USBR					
Sacramento River	Monticello	Putah Creek	29	8N	2W	50	5	700	1950	USBR	400	10	500	1946	USBR
Sacramento River	Noyes	Putah Creek	30	11N	5W	200	20	950	1955	DWR					
Sacramento River	Glasscock	Cache Creek	3	12N	4W	200	20	900	1955	DWR					
Sacramento River	Hunter Point	Cache Creek	25	16N	10W	1,000	10	1,600	1929	USCE					
Sacramento River	Indian Valley	N. F. Cache Creek	9	14N	6W	50	5	1,545	1946	USBR	400	10	1,490	1946	USBR
Sacramento River	Wilson Valley	Cache Creek	19	13N	5W	400	10	1,110	1946	USBR	400	10	1,110	1946	USBR
Sacramento River	Golden Gate	Funks Creek	9	17N	4W										
Sacramento River	Black Mountain	Stone Corral Creek	20	17N	4W	500	25	400	1952	DWR					
Sacramento River	Fruto	Nye Creek	16	20N	5W	450	20	860	1952	DWR	450	20	860	1952	DWR
Sacramento River	High Peak	Hunters Creek	9	18N	4W	200	20	310	1956	DWR					
Sacramento River	Mountain House	Freshwater Creek	19	15N	4W	500	25	700	1954	DWR	500	25	700	1954	DWR
Sacramento River	Schoenfield	Redbank Creek	16	26N	6W	500	20	1,000	1953	DWR	450	20	1,000	1953	DWR
Sacramento River	Sites	Stone Corral Creek	20	17N	4W	500	10	500	1956	DWR					
Sacramento River	Squaw Flat	Logan Creek	29	19N	4W	100	10	310	1956	DWR					

ALTERNATIVE PLANS FOR DEVELOPMENT

PART II

SUMMARY PLATES

INTRODUCTION

One of the department's primary objectives in the reconnaissance investigation of the North Coastal area has been to sort out the large number of physically possible plans for water development and determine which alternatives should be selected for further consideration and more detailed study. The studies have involved making comparisons among many proposed projects which in turn demanded that the principal parameters of each such as cost, yield and capacity be evaluated. The nature of the studies has demanded a tremendous amount of information. A problem of no small significance has been that of maintaining an orderly file of the data, computations and other supporting material pertinent to the studies.

The summary plates evolved as an attempt to meet the problem of preserving and presenting information in a logical and orderly way. Each plate presents information by graphical illustrations on some phase of the North Coastal Area Investigation. Some of the plates present comparisons of alternative plans for developing certain streams. Others show the relationships among parameters of a single plan. In any case, the plate summarizes a study of a proposed development and presents information such that the costs and water yield accomplishments of the development, generally, are readily discernible.

Each plate is organized along the same format. On the left side a plan and profile of the subject development are shown. A series of charts are presented on the right which graphically illustrate basic data and information obtained in the study that is applicable to the proposed facilities. Generally, the charts are arranged in the following order:

1. Reservoir area-capacity-elevation data
2. Reservoir yield-capacity relationships
3. Reservoir cost-capacity relationships
4. Conveyance facilities cost-capacity relationships

5. Hydroelectric powerplant cost-capacity-revenue relationships
6. Total project capital cost-annual yield relationships
7. Total project net annual unit cost-annual yield relationships.

Since the plates were prepared at different times and based upon the basic data which was then available and upon the assumptions of a particular study, a few inconsistencies may be found in comparing plates. For this reason, the date of preparation, rather than the publishing date of this report is shown on the title block of each plate. Preceding each plate in this volume is a narrative description of the particular study, the sources of data, assumptions and key points of each chart.

The summary plates contain a tremendous amount of valuable information. It should be recognized however, that they do not reflect some important factors which must be considered prior to the final selection of the plan for development of a North Coastal stream. These factors include the recreational value of proposed reservoirs; flood protection benefits; the total effect of a project on fish and wildlife; the impact on a local area resulting from the inundation of lands by a proposed reservoir; and the aesthetic value or detriment associated with a proposed project.

GENERAL INFORMATION

Criteria and Methods Used in Power Studies

The department's planning engineers have investigated a great number of possible hydroelectric power developments in the North Coastal area. Basically the steps taken in the investigations were as follows:

1. The maximum dependable capacity in kilowatts was determined for a proposed powerplant based upon the water supply and head which could be sustained during the most critical drought period, with the plant operating on a 30 percent capacity factor.
2. The annual revenue from the sale of electrical power was computed based upon an annual value at the Tesla load center of $26.30 per kilowatt of dependable capacity and 3.13 mills per kilowatt-hour of generated energy. It was estimated that transmission costs and line losses would reduce these values at the plants to approximately $22 per kilowatt of dependable capacity and 3 mills per kilowatt-hour of generated energy. It was also

considered that additional power revenues would be obtained during wet years from the sale of secondary energy at 3 mills per kilowatt-hour.

3. The annual costs of the power plant and the associated facilities were estimated as indicated below. The powerplant was included in the proposed development when the annual power revenues exceeded the annual costs of the power facilities.

On February 11, 1964, the department's power office under the Chief Engineer informed the Northern Branch, by memorandum, that the annual value of hydroelectric power may decrease to about $17 per kilowatt of dependable capacity and 0.75 mill per kilowatt-hour of generated energy at future powerplants located in the North Coastal area. The new value is based upon the cost of power generated by an alternative modern steam-electric plant with extremely high generating capacity. The plant would have multiple units and would utilize both nuclear and fossil fuels. Needless to say, many powerplants which are shown on the summary plates would not be recommended if this revised value for hydroelectric power had been used in the analysis.

Value of Power at Pumping Plants

The value of electrical power at the pumping plants in the North Coastal Area Investigation was also based upon its value at the Tesla load center plus the cost of transmission lines. Generally, the capacity charge used for unrestricted pumping amounted to about $29 per kilowatt-year. Electrical energy was considered to have a value of 3.3 mills per kilowatt-hour at the plant. It was also considered that there would be a maximum of 4,380 hours during each year in which off-peak power would be available. The capacity charge for off-peak power was considered to be equivalent to the cost of transmission to the plant.

The power office memorandum of February 11, 1964, indicates that a major reduction in the future value of power for pumping will also occur. The new power values will have a great effect upon the selection between specific alternatives but its overall effect upon the net cost of the total North Coastal development may not be of major significance.

Cost Estimates

The costs estimated for the proposed power and pumping plants were generally obtained from cost versus capacity curves developed from construction costs of existing plants of similar capacity and head. The curves were prepared so that lump sum estimates could be made of the following components of each plant;

1. Basic plant consisting of:
   a. Structure and improvements
   b. Turbines and generators or pumps and motors
   c. Accessory electrical equipment
   d. Miscellaneous equipment
2. Electrical substation
3. Penstocks or discharge pipes.

The costs of dams, reservoirs and tunnels were estimated by the Northern Branch Design Unit in most cases. These estimates vary in quality but are generally of a reconnaissance order. In order to estimate the optimum size of these facilities, cost versus capacity curves were prepared which required estimates at a range of sizes.

Water Yield

The amount of water which a proposed reservoir would be expected to yield was determined from simulated operation studies of the reservoir based upon historical runoff at the damsite. On some streams such as the upper main Eel River there is an existing development and the new yield from an additional reservoir would be only the additional supply of water which could be produced. In general, it was assumed that the full water supply would be sustained without deficiencies, although there are some exceptions which are indicated on the plates. The plates also indicate the location where the water supply would be delivered and the schedule of delivery; i.e., uniform, power, irrigation, urban or combination irrigation-urban.

PLATE 1
ENGLISH RIDGE PROJECT
Export to Russian River and Clear Lake

The data shown on this plate were developed to indicate the approximate capital and annual costs of the proposed English Ridge Dam and Reservoir and the associated power and conveyance facilities, when constructed to supply water to the Russian River Basin and the Clear Lake Basin. The estimated annual unit costs of the delivered water are based on the premise that the total project yield would be saleable in the first year of operation.

CHART A: Reservoir Area - Capacity Data - English Ridge Reservoir

These data were determined for the damsite located in Section 6, T19N, R12W, MDB&M, with the streambed elevation at approximately 1,180 feet.

The water surface elevation vs. area data were determined by planimetering the Department of Water Resources' English Ridge Reservoir map, produced by photogrammetry, dated April 19, 1962, scale 1:4800, at the contour interval of 20 feet. The elevation vs. capacity data were computed by the average area method.

CHART B: Reservoir Yield - Capacity Data

The reservoir total yield potential curve indicates the amount of water which could be diverted annually to Potter Valley from English Ridge Reservoir on a typical power schedule. It was assumed that Lake Pillsbury would remain full during years which have normal runoff. In a critical period, releases would be made from Lake Pillsbury after English Ridge Reservoir had been drawn down to minimum pool.

The net new divertible yield potential curve indicates the new yield attributed to English Ridge Reservoir when the reservoir inflow is considered to be the sum of the present impaired spills over Van Arsdale Dam plus the downstream accretions. This new yield is the annual incremental diversion which would not deplete the yield from existing or proposed reservoirs on the Russian River.

CHART C: Reservoir Cost - Capacity Data

The capital cost curve is based on estimates which were prepared to preliminary standards by the Northern Branch Design Unit. The cost estimates were prepared for earthfill dams of varying heights at the English Ridge site immediately below the junction of Old Woman Creek and the Eel River.

The costs were estimated for reservoirs with normal water surface elevations of 1550, 1650, and 1690 feet, and storage capacities of 580,000, 1,300,000, and 1,720,000 acre-feet, respectively.

CHART D: Potter Valley Diversion Cost - Rate Data

The capital and annual cost curves on this chart indicate the cost of the new diversion facilitites to Potter Valley and include the cost of a new Potter Valley powerplant and afterbay. The cost of purchasing the existing power facilities from the Pacific Gas and Electric Company was included in the annual cost curve. This annual cost was based on the plants installed capacity of 9,040 kilowatts and its mean annual energy generation during 1951-60, inclusive of 65,144,640 kilowatt hours. The powerplant operation and maintenance cost during a typical year (1957) was $32,000.

The top horizontal scale on the chart indicates the dependable powerplant capacity that could be sustained by English Ridge Reservoir when constructed at a capacity sufficient to develop the new yield shown on the bottom horizontal scale.

In this study, the new yield was considered to be the additional annual diversion through the powerplant during a critical period as the result of the storage provided in English Ridge Reservoir.

The power schedule used in this investigation was:

Month	KWH/KW	Percent
Oct.	200	7.605
Nov.	170	6.464
Dec.	180	6.844
Jan.	160	6.084
Feb.	140	5.323
Mar.	220	8.365
Apr.	190	7.224
May	200	7.605
June	260	9.886
July	330	12.547
Aug.	340	12.928
Sept.	240	9.125
TOTAL	2,630	100.00

Plant Capacity Factor = 30%

CHART E: Clear Lake Diversion Cost - Rate Data

These data indicate the capital and annual costs of transporting water from English Ridge Reservoir to Clear Lake by alternative methods.

One method would be by direct diversion through the proposed Garrett Tunnel. It was assumed that the tunnel could be sized for continuous uniform flow, since any monthly "peaking" that would be required could be done at Clear Lake with no significant change in its water level. The inlet elevation of Garrett Tunnel would be at 1,500 feet, and the inactive storage capacity at English Ridge R servoir at this elevation would be 360,000 acre-feet.

The alternative method would entail making a power drop from English Ridge Reservoir on a power schedule to power facilities in Potter Valley. The new net divertible yield would be conveyed by a canal and tunnel to a forebay on Cold Creek. The water would then be pumped over the Cold Creek-Scott Creek Divide into the Clear Lake Basin. In order to match the power release, the capacity of the conveyance facilities was considered to be such that 13 percent of the total annual yield could be conveyed in one month. The inlet elevation of the English Ridge-Potter Valley Diversion Tunnel would be at 1,475 feet, and the inactive storage capacity of English Ridge Reservoir at this elevation would be 300,000 acre-feet.

CHART F: Annual Unit Cost of Delivered Water

These data indicate the annual unit cost of water in dollars per acre-foot when the net new divertible yield is:

A. Stored in English Ridge Reservoir.

B. Released in addition to the existing diversion through the proposed Potter Valley power facilities into the Russian River Basin.

C. Delivered to Clear Lake by the Potter Valley Pump Diversion method.

D. Delivered to Clear Lake through the proposed Garrett Tunnel.

It should be noted that these data indicate that when the annual delivery is less than 400,000 acre-feet, the Potter Valley Pump Diversion method of delivering water to Clear Lake would be superior to the Garrett

Tunnel method. The net new divertible yield from English Ridge Reservoir would be a maximum of 368,000 acre-feet.

CHART G: Annual Unit Cost of New Water Yield

These data indicate the annual unit cost of water in dollars per acre-foot when a portion of the new yield from English Ridge Reservoir is delivered to Clear Lake, and the remainder is released to the Russian River.

An example for the use of the data on this chart can be shown as follows: Determine the unit cost of water if the English Ridge Project is sized so that it will develop 300,000 acre-feet of new annual yield with 100,000 acre-feet delivered annually to Clear Lake and the remaining 200,000 released annually to the Russian River. Reading from Curve "A", it can be observed that when the total new yield is 300,000 acre-feet per year, the unit cost of water released to the Russian River from the Potter Valley afterbay would be approximately $10 per acre-foot. The additional conveyance cost shown by Curve "B" is $12 per acre-foot. Reading from Curve "C", it is observed that the unit cost of delivering 100,000 acre-feet per year to Clear Lake would be approximately $22 per acre-foot.

CHART H: Capital Cost of New Water Yield

These data indicate the capital cost of water when a portion of the new yield from English Ridge Reservoir is delivered to Clear Lake, and the remainder is released to the Russian River. Charts G and H are identical in their respective treatment of annual unit cost and capital cost. These data were based on an inactive storage capacity in English Ridge Reservoir of 300,000 acre-feet at elevation 1,475 feet.

CHART C

RESERVOIR COST - CAPACITY DATA

ENGLISH RIDGE DAM AND RESERVOIR ONLY

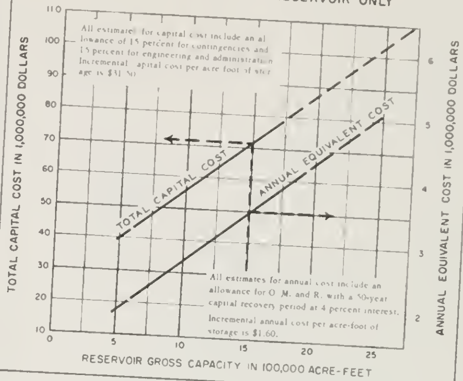
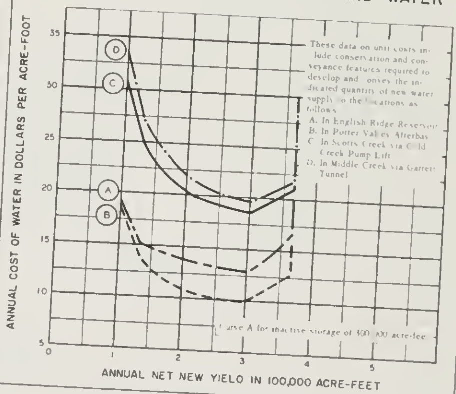


CHART F

ANNUAL UNIT COST OF DELIVERED WATER



Note:

The annual value of hydroelectric power is considered to consist of two components; capacity and energy.

1. Dependable capacity per kilowatt year $2[illegible].00.
2. Useable energy per kilowatt hour 3 mills.

The project power plants would operate 50 percent of the time at dependable capacity.

The annual cost of "on peak" pumping capacity is $24.40 per kilowatt and energy cost is 3 mills per kilowatt hour.

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION

UPPER EEL RIVER DIVISION

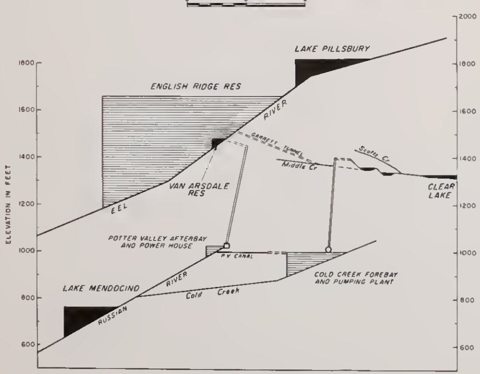
1964

ENGLISH RIDGE PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR EXPORT OF EEL RIVER WATER SUPPLIES TO THE RUSSIAN RIVER BASIN AND CLEAR LAKE AREA

PLAN

SCALE OF MILES



PROFILE

NO HORIZONTAL SCALE

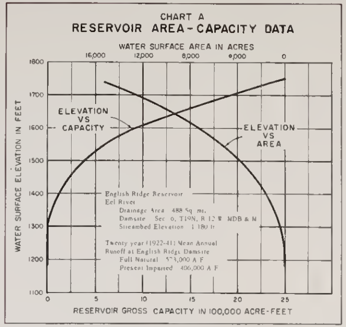


CHART A
RESERVOIR AREA-CAPACITY DATA

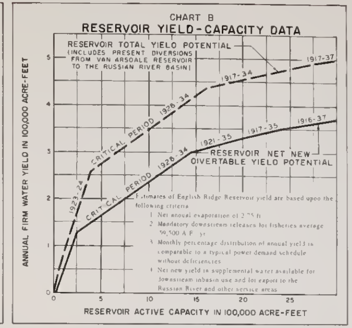


CHART B
RESERVOIR YIELD-CAPACITY DATA

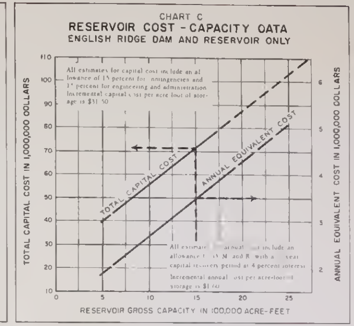


CHART C
RESERVOIR COST-CAPACITY DATA
ENGLISH RIDGE DAM AND RESERVOIR ONLY

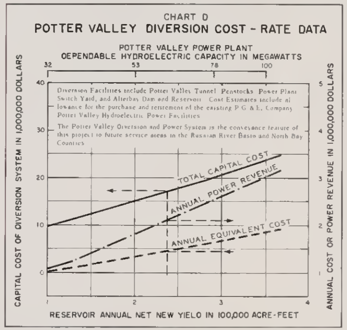


CHART D
POTTER VALLEY DIVERSION COST-RATE DATA

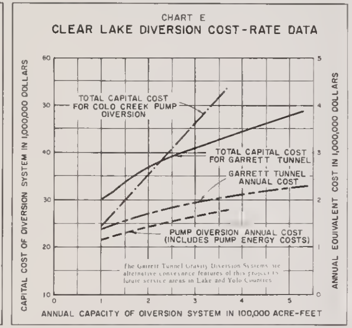


CHART E
CLEAR LAKE DIVERSION COST-RATE DATA

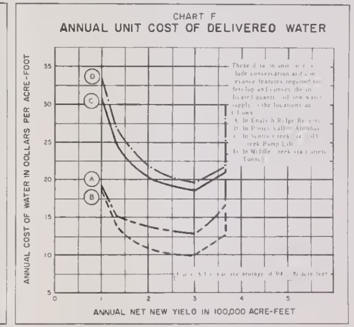


CHART F
ANNUAL UNIT COST OF DELIVERED WATER

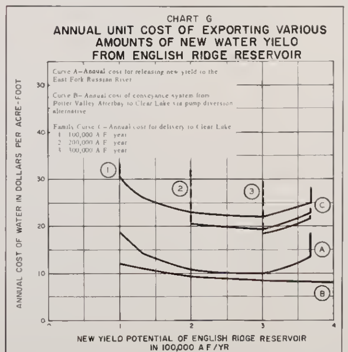


CHART G
ANNUAL UNIT COST OF EXPORTING VARIOUS AMOUNTS OF NEW WATER YIELD FROM ENGLISH RIDGE RESERVOIR

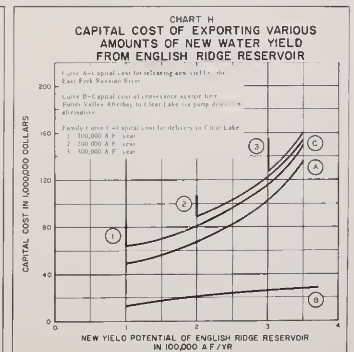


CHART H
CAPITAL COST OF EXPORTING VARIOUS AMOUNTS OF NEW WATER YIELD FROM ENGLISH RIDGE RESERVOIR

Note-

The annual value of hydroelectric power is considered to consist of two components; capacity and energy.

1. Dependable capacity per kilowatt year. $22.[illegible]
2. Useable energy per kilowatt hour 3 mills.

The project power plants would operate 50 percent of the time at dependable capacity.

The annual cost of "on peak" pumping capacity is $24.40 per kilowatt and energy cost is 3 mills per kilowatt hour.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION
UPPER EEL RIVER DIVISION
1964

ENGLISH RIDGE PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR EXPORT OF EEL RIVER WATER SUPPLIES TO THE RUSSIAN RIVER BASIN AND CLEAR LAKE AREA

PLATE 2 . . . Deleted

PLATE 3

THE GLENN RESERVOIR COMPLEX

With Imports From the Middle Fork of the Eel River

Plate 3 was prepared in 1961 in order to summarize costs and other pertinent data of the Glenn Reservoir Complex for conditions with and without imports from the Middle Fork Eel River. Imports from other possible sources were not considered in the preparation of this plate. Additional information on the potential achievements of the Glenn Reservoir Complex is shown on Plate 12.

The new water yield accomplishments of this reservoir complex shown on Plate 3 are based on a uniform monthly distribution of firm annual yield without deficiencies. This is quite probably not the new yield release distribution the reservoir would operate on to enhance water yield in the delta. However, at this stage of the studies, the uniform schedule provides a convenient basis for comparing alternative projects.

The storage-yield curves shown on this plate were developed for two limiting conditions of annual water yield, "gross yield" and "net yield". "Gross yields" were based on conditions of assuming full natural reservoir inflow to be storable while "net yields" were derived on the assumption that the reservoir complex would operate as an increment above the existing and near future Central Valley Reservoir system. In the latter case, it was assumed that the only time water could be stored on Thomes and/or Stony Creeks was when that water was not serving a prior beneficial downstream purpose. All present and contemplated near future water demands of the Orland Project and Black Butte Reservoir were met in the latter case. In all cases, imports from the Middle Fork Eel River enter Glenn Reservoir on a random schedule, corresponding to the plan of diverting the greatest possible amount of Eel River water in a given time.

This plate also includes summary data of a reconnaissance evaluation of one of the more favorable plans for developing the power potential of the Glenn Reservoir Complex. Indications are that for the range of flows considered, i.e., up to 600,000 acre-feet annually, that a power development may be feasible, but the expected net revenue probably would be less than about $2.00 per acre-foot of net new yield. It is anticipated that additional power studies will be made in the future.

It should be noted that data presented on this plate are based on specific assumptions as discussed in the following chart explanations. Any conclusions made on the basis of this plate should be viewed in full light of the inherent limitations and the assumptions made.

CHART A:

This chart sets forth area-elevation-capacity data for the various elements of the Glenn Reservoir Complex. These data were developed from the Department of Water Resources' Glenn Reservoir Map, dated July 1960, scale: 1" = 1000', contour interval = 20'. This map is available also at a scale of 1" = 400'.

CHART B:

Chart B is an evaluation of the average annual volume of water that can be diverted from Spencer Reservoir to the Glenn Reservoir Complex by various combinations of reservoir and tunnel sizes within a given period. In this case, it was assumed that the critical period for future coordinated reservoir operations within the Central Valley Basin would be from June 1928 through October 1937. The difference between the curves representing divertible water (dashed lines) and the firm yield curve (solid line) is the amount of water that can be developed by Sacramento Valley regulatory storage. This is only true, however, if Spencer Reservoir is operated to divert water as fast as possible. If the reservoir is operated on the basis of a uniform monthly distribution of annual yield, rather than diverting water as fast as possible, the amount of holdover storage available to store high flows would be less. Consequently, the amount of water that could be diverted would be less. Operating on the basis of diverting flows as fast as possible, therefore, negates the possibility of obtaining firm yield from this project. The horizontal line at the top of the chart represents mean annual runoff for the period under study. The slanting line at the top of the chart labeled "maximum exportable water" is equivalent to inflow plus storage minus local releases and evaporation on an annual basis for the period under study. These curves were based on monthly reservoir operation studies. Correction for reservoir evaporation was based on the storage at the beginning of the month.

Schedules of releases from Spencer Reservoir for fish and local irrigation are as follows:

Month	Fish Release (Acre-Feet)	Local Irrigation Release (Acre-Feet)	Total (Acre-Feet)
January	6,000	---	6,000
February	6,000	---	6,000
March	4,200	---	4,200
April	4,200	1,600	5,800
May	4,200	3,900	8,100
June	4,200	6,000	10,200
July	2,400	6,200	8,600
August	2,400	5,700	8,100
September	2,400	2,600	5,000
October	6,000	---	6,000
November	6,000	---	6,000
December	6,000	---	6,000
TOTAL	54,000	26,000	80,000

Fish life maintenance and enhancement releases, amounting to 54,000 acre-feet annually, were estimated by California Department of Fish and Game Fisheries Biologists under contract to the Department of Water Resources. The annual release of 26,000 acre-feet for local irrigation in Round Valley was estimated by the U. S. Bureau of Reclamation. The monthly schedule of irrigation use was inferred from the distribution of use in Potter Valley during the year 1959.

CHART C:

Chart C presents the same information for the period June 1916 through October 1937 that Chart B presents for the shorter period.

CHART D:

Chart D is an analysis of the diversion potential of Jarbow Reservoir. Essentially this chart is the same type of analysis for Jarbow Reservoir that Chart B is for Spencer Reservoir. The only important difference in the analysis is that in the case of Jarbow Reservoir, the irrigation requirements of Round Valley are to be met by upstream reservoirs rather than by the diversion reservoir.

CHART E:

Chart E is an analysis of the diversion potential of Jarbow Reservoir for the period June 1916 through October 1937. Otherwise it is similar to Chart D which is an analysis for the shorter period, June 1928 through October 1937.

CHART F:

This chart shows the relationship between the amount of water diverted and the cost per acre-foot thereof. The cost shown is the lowest cost of the several possible combinations of reservoir and tunnel cost for a given average annual diversion rate.

The costs for Spencer Reservoir and the several possible tunnel alignments from both Spencer and Jarbow meet good reconnaissance standards. However, the cost data for Jarbow Reservoir are not complete. The annual cost per acre-foot of diverted water is equal to annual cost divided by the average annual amount of water diverted.

CHART G:

Chart G presents storage-yield data for Glenn Reservoir with conditions of local inflow. Local inflow is defined as only those flows which originate within the watersheds of Paskenta, Newville, and Rancheria Reservoirs. The major streams of these watersheds are: Stony Creek, North Fork Stony Creek, and Thomes Creek. The flows of Stony Creek and the North Fork of Stony Creek are based upon data from a March 1958, U. S. Corps of Engineers' operation of Black Butte Reservoir. Flows of Thomes Creek at Paskenta from 1922 to date, are available in U.S.G.S. water supply papers. Estimates of flows prior to this time are from Bulletin No. 1, "Minor Sacramento Valley Streams". These latter flows were obtained by straight line correlation with the Sacramento River at Red Bluff. The yield shown on this chart is distributed on a uniform monthly schedule, with no deficiencies.

Present demands or those anticipated in the near future which are now being met or than can be provided for by existing facilities and facilities nearing completions are treated as depletions from natural flows. These demands are as follows:

1. Orland Irrigation District requirements.
2. Black Butte "New Lands" conservation requirements.

3. Those portions of Stony and Thomes Creek flows which contribute to the prior downstream mandatory requirements in the Sacramento River and Sacramento-San Joaquin Delta.

As stated, these demands were subtracted from natural flows; the remaining flows were used to calculate the curves labeled "net yield". Full natural flows were used to determine the "gross yield" curves.

A new yield of about 49,300 acre-feet is attributed to development of Stony Creek flows by conservation features of Black Butte Reservoir. A market for this yield, in which deficiencies are taken, is guaranteed by the State of California. However, no contracts have been concluded to date. It is possible that this water may be used in the Bureau's West Sacramento Canal service area. It is doubtful that Black Butte Reservoir would be able to achieve regulation such as to make these flows usable in the Delta. If this water were to be used in the Delta, a greater yield could probably be obtained by storing this water in Glenn Reservoir than could be obtained by storing it in Black Butte Reservoir. What this incremental yield might be has not been determined.

As stated, releases are also assumed to be made when the natural flows of Stony Creek or Thomes Creek contribute to the existing mandatory flows in the Sacramento River and Delta. The amount and timing of these releases depend on the surplus flows or lack of them which is assumed to exist in the Sacramento-San Joaquin Delta. Surplus flows determined by the USBR-State Joint Operation of September 1960, were used to determine mandatory releases. The estimates of Delta flows are constantly being revised and consequently, the mandatory releases are subject to change. One of the differences between the gross and net yield curves is attributable to this mandatory release effect.

A portion of the estimated Sacramento River mandatory release schedule is for navigation purposes. Although these possibly required mandatory releases for navigation purposes represent only a small part of the difference between the gross yield and net yield curves, it may be possible that the navigation requirements need not be subtracted from inflows since releases would probably be made to the river at this time anyway. All estimates are based on the assumption that existing Central Valley Reservoir System would continue to operate according to present criteria.

Through coordination of these alternative Middle Fork Eel River Diversion Projects and elements of the Glenn Reservoir Complex with the Central Valley Reservoir System, it seems reasonable, however, to theorize that actual yields of these projects would be neither as high as shown by the "gross yield" curve nor as low as indicated by the "net yield" curve.

Both net and gross yield curves are corrected for evaporation according to the following schedule:

Storage (1,000,000 Acre-Feet)	Annual Evaporation Loss (1,000 Acre-Feet)
1	30
2	50
3	70
4	85
5	95

CHART H:

This chart indicates the relationships between reservoir storage capacity and capital and annual cost data for the various possible combinations of the components of Glenn Reservoir. Total annual cost is assumed to equal 5 percent of the capital cost. These curves are based on estimates made by the Northern Branch design group for four normal pool elevations; 860, 920, 960, and 1,000 feet above mean sea level.

A report on the quantity and quality of borrow material available for Rancheria, Newville, and Julian Rocks Dams is nearing completion. This information may lead to some revisions in cost estimates.

Cost of a road around Glenn Reservoir is included but the cost of a causeway and bridge across Chrome Saddle is not.

CHART I:

This chart shows the relationship between the net yield derived from local sources of inflow and the cost per acre-foot of developing this yield. The only cost considered to be incurred by the development of local water is that of the dam and reservoir. Recreation benefits, which would probably be appreciable, have not been credited. The relationships shown on this chart are sensitive to the changes in cost and changes in demand schedule.

CHART J:

Chart J presents the yield-storage capacity data for Stony Creek plus imports from the Middle Fork Eel River. These imports would originate at either Jarbow Reservoir or Spencer Reservoir. The conveying tunnel would have its downstream portal in the Grindstone Creek Basin in either case; however, the elevation of the exit inverts would be different. The Jarbow-Grindstone tunnel would have an exit elevation of 1,000 feet while the Spencer-Grindstone tunnel would have an exit of 1,250 feet. The gross storage capacities for Jarbow and Spencer Reservoirs were assumed to be 285,000 acre-feet and 532,000 acre-feet respectively. The sizing of Spencer Reservoir at 532,000 acre-feet of storage, under the assumed operation, was done on a reasonably sound basis. The basis for sizing Jarbow Reservoir was not as firm. These diversion reservoirs were operated in the manner described in the section titled "Chart B". Both gross yield and net yield curves are shown. The difference between these curves is described in the section headed "Chart G". More pertinent data on these features are given in Chart N.

CHART K:

Chart K presents the yield-storage capacity data for Thomes Creek plus an import from Spencer Reservoir. The transbasin diversion would be accomplished by a tunnel from Spencer Reservoir to Thomes Creek which would exit at elevation 1,250. It does not appear feasible to develop the power potential between the tunnel outlet portal and Paskenta Reservoir. Both gross yield and net yield curves are shown on this chart. The difference between these is explained under the heading "Chart G".

CHART L:

Chart L presents yield-storage data based upon Stony Creek flows plus Thomes Creek flows plus a diversion from either Spencer or Jarbow Reservoirs. The Middle Fork Eel River Reservoirs are operated as diversion reservoirs as discussed above. Both tunnels would exit in the Grindstone Canyon. The outlet invert elevations are 1,250 feet for the tunnel from Spencer and 1,000 feet for the tunnel from Jarbow. The difference between the gross yield and net yield curves is discussed in the section headed "Chart G".

CHART M:

Chart M presents a table of pertinent data for the Middle Fork Eel River features and the transbasin diversion features which are used in the development of yield-storage relationships presented on this chart. These features are regarded as constants in this analysis.

CHART N:

Chart N presents capital cost-yield data for the various alternative projects considered herein. The following is a breakdown of the features which costs are included in the curves.

Curve A:	Spencer Reservoir Spencer-Thomes Tunnel Paskenta Reservoir Newville Reservoir 1/
Curve B:	Spencer Reservoir Spencer-Grindstone Tunnel Rancheria Reservoir 1/ Newville Reservoir 2/
Curve C:	Jarbow Reservoir Jarbow-Grindstone Tunnel Rancheria Reservoir 1/ Newville Reservoir 2/
Curve D:	Spencer Reservoir Spencer-Grindstone Tunnel Paskenta-Newville-Rancheria Reservoir 3/
Curve E:	Jarbow Reservoir Jarbow-Grindstone Tunnel Paskenta-Newville-Rancheria Reservoir 3/

1/ Including the cost of Chrome Dike.
2/ Only used for total storages in excess of 3,750,000 acre-feet: including the cost of a cut across Chrome Saddle and a causeway.
3/ Includes the cost of the cut and causeway-bridge across Chrome Saddle.

The cost of the Middle Fork Eel River reservoirs and the transbasin tunnels are not varied within a given study. The only variance in cost is due to the sizing of the Glenn Reservoir complex features.

Since Jarbow and Spencer Reservoirs were operated so as to preclude the development of firm yield, the total costs at low yields are high. Costs for all features shown are still under study.

CHART O:

This chart shows the net revenue attributable to power development below the Glenn Reservoir Complex. Consideration was limited to the development of the power potential below Newville Reservoir. On the basis of preliminary studies it appears feasible to develop the power head between Newville and Black Butte Reservoirs, either by means of channel excavation or by construction of an intermediate reservoir. Indications are that for a low range of flows the intermediate reservoir would be more advantageous, whereas with higher flows, the excavation appears more favorable. The evaluation shown on this chart is based on construction of the intermediate reservoir.

The net revenue declines sharply for yields greater than about 460,000 acre-feet. This is because a large active storage capacity is required to develop these yields and the corresponding dam costs are increasing at a much greater rate than power benefits.

This chart indicates that although a power development may be feasible, the expected net revenues are not appreciable.

CHART P:

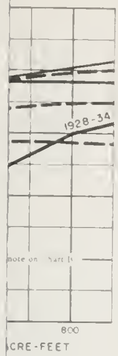
This chart gives yield and annual cost data for the same alternatives shown in Chart N. The curve notation is the same.

Costs and benefits associated with flood control, hydro-power, recreation, and fisheries enhancement are not included in this analysis. The data shown do not reflect costs associated with construction of the proposed highway from the vicinity of Orland to the vicinity of Willits via a Mendocino Pass route. A bridge across the Chrome Channel portion of the Glenn Reservoir Complex probably would be required for this highway and its cost would be assigned to the project.

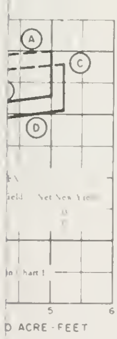
As mentioned previously, conclusions made from these charts should be viewed in light of the basic assumptions made. As an example, the lowest unit cost indicated on this chart is for Newville-Paskenta Reservoir with an import from Spencer Reservoir. However, previous coordinated operations with the delta show that a combination including Rancheria and Spencer Reservoirs could firm-up delta supplies at a lower unit cost than could the Newville-Paskenta-Spencer combination.

There are a number of contributing factors which lead to these different conclusions. One of the major ones is the different demand schedules used in the two analyses. A uniform demand schedule was used in the former and a delta-firming schedule was used in the latter. The effect of using a uniform demand schedule varies as the inflow pattern and the storage capacities involved. The effect is not so evident in the month-to-month variation as it is in the year-to-year variation. When viewed on the latter basis, it appears that somewhat larger storages would be required to meet a delta demand schedule than a uniform demand schedule. This would be true when the demand is less than average for a period of several years, when the inflow is high during this same period, and then the demand becomes higher for a shorter period of years when the inflow is not so great. The concurrence of low demand and high inflow changes the point at which the reservoir would break over into a longer critical period which in turn would change the required storage for a given yield. The effect is particularly noticeable in a critical period lasting 20 years or more.

RIVER FLOWS
R 1937
ERVOIR



ONSHIPS
EEK ONLY
EEL RIVER



F
M YIELD
IOMES CREEKS
EEL RIVER

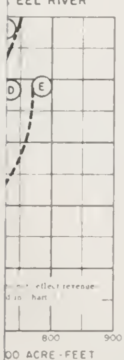


CHART E
EXPORTABLE MIDDLE FORK EEL RIVER FLOWS
DURING THE PERIOD
JUNE 1916 THROUGH OCTOBER 1937
DIVERSION FROM JARBOW RESERVOIR

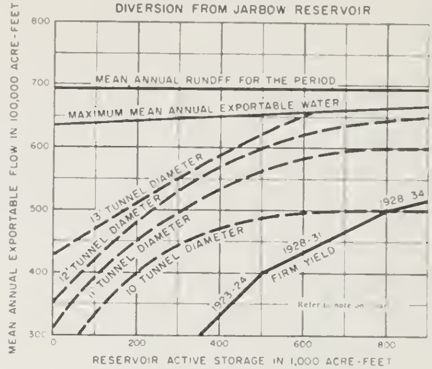
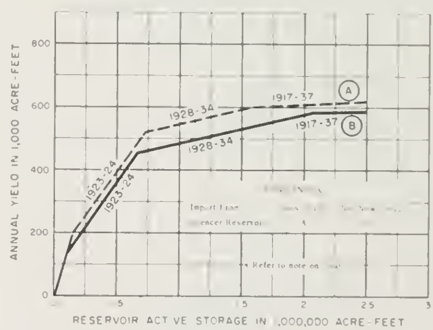


CHART K
FIRM WATER YIELD-
STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM THOMES CREEK ONLY
PLUS IMPORTS FROM MIDDLE FORK EEL RIVER



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NORTH COASTAL AREA INVESTIGATION
UPPER EEL RIVER DIVISION
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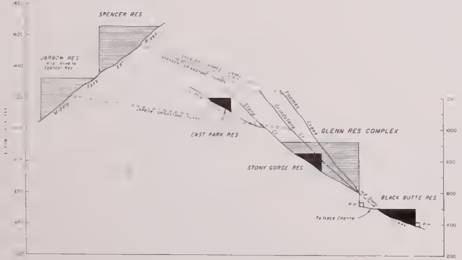
THE GLENN RESERVOIR COMPLEX

RECONNAISSANCE SUMMARY OF COST FOR
DEVELOPMENT OF NET NEW FIRM WATER YIELD AT SITE
RESERVOIR INFLOWS DERIVED FROM NATURAL TRIBUTARY
RUNOFF AND IMPORTS FROM MIDDLE FORK EEL RIVER

PLAN



PROFILE
NO HORIZONTAL SCALE

CHART A
AREA-ELEVATION-CAPACITY DATA
THE GLENN RESERVOIR COMPLEX

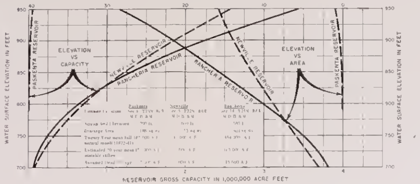


CHART B
EXPORTABLE MIDDLE FORK EEL RIVER FLOWS
DURING THE PERIOD
JUNE 1928 THROUGH OCTOBER 1937
DIVERSION FROM SPENCER RESERVOIR

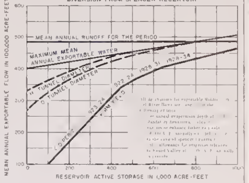


CHART C
EXPORTABLE MIDDLE FORK EEL RIVER FLOWS
DURING THE PERIOD
JUNE 1916 THROUGH OCTOBER 1937
DIVERSION FROM SPENCER RESERVOIR

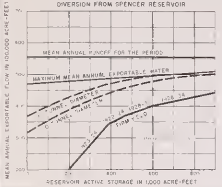


CHART D
EXPORTABLE MIDDLE FORK EEL RIVER FLOWS
DURING THE PERIOD
JUNE 1928 THROUGH OCTOBER 1937
DIVERSION FROM JARBOW RESERVOIR

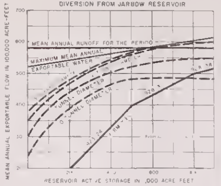


CHART E
EXPORTABLE MIDDLE FORK EEL RIVER FLOWS
DURING THE PERIOD
JUNE 1916 THROUGH OCTOBER 1937
DIVERSION FROM JARBOW RESERVOIR

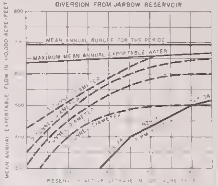


CHART F
ESTIMATED UNIT COST OF IMPORTED MIDDLE FORK EEL RIVER WATER SUPPLIES TO THE GLENN RESERVOIR COMPLEX FROM SPENCER OR JARBOW RESERVOIRS

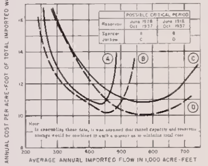


CHART G
FIRM WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM STONY AND THOMES CREEKS ONLY

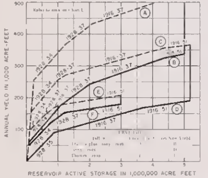


CHART H
ESTIMATED COST-STORAGE CAPACITY RELATIONSHIPS
FOR ELEMENTS OF THE GLENN RESERVOIR COMPLEX

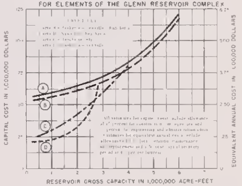


CHART I
ANNUAL UNIT COST OF DEVELOPING NET NEW FIRM YIELD
INFLOW DERIVED FROM STONY AND THOMES CREEKS

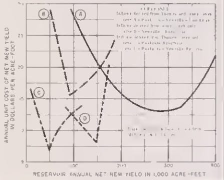


CHART J
FIRM WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM STONY CREEK ONLY PLUS IMPORTS FROM MIDDLE FORK EEL RIVER

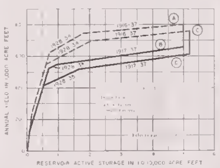


CHART K
FIRM WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM THOMES CREEK ONLY PLUS IMPORTS FROM MIDDLE FORK EEL RIVER

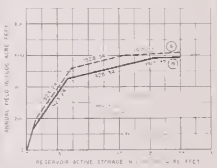


CHART L
FIRM WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM STONY AND THOMES CREEKS PLUS IMPORTS FROM MIDDLE FORK EEL RIVER

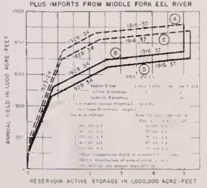


CHART M
TABULATION OF MIDDLE FORK EEL RIVER FEATURES USED IN GLENN RESERVOIR COMPLEX YIELD ANALYSES

PLAN	JARBOW -RANCHERIA	SPENCER -RANCHERIA	SPENCER -NEWVILLE
DIVERSION RESERVOIR	JARBOW	SPENCER	SPENCER
RESERVOIR CAPACITY	285,000 A.F	532,000 A.F	532,000 A.F
TUNNEL DIAMETER	12 FEET	10 FEET	10 FEET
CAPITAL COST	$ 124,000,000	$ 87,600,000	$ 93,400,000
ANNUAL COST	$ 6 200,000	$ 4,360,000	$ 4,870,000
TUNNEL LENGTH	23.2 MILES	15.1 MILES	20.1 MILES
TUNNEL OUTLET LOCATION	GRINDSTONE CREEK	GRINDSTONE CREEK AT SHEPERD CR	THOMES CREEK
TUNNEL OUTLET ELEVATION	1,000 FEET	1,250 FEET	1,250 FEET

CHART N
NET YIELD-CAPITAL AND ANNUAL COST DATA ELEMENTS OF GLENN RESERVOIR COMPLEX
WITH IMPORTS FROM MIDDLE FORK EEL RIVER

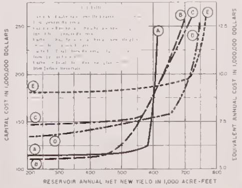


CHART O
RELATIONSHIP OF POTENTIAL NET HYDRO POWER REVENUE TO PROJECT NET NEW CONSERVATION YIELD

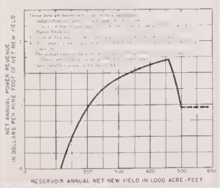
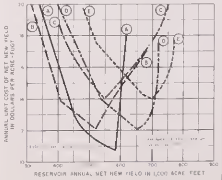


CHART P
ANNUAL UNIT COST OF DEVELOPING NET NEW FIRM YIELD
INFLOW DERIVED FROM STONY AND THOMES CREEKS PLUS IMPORTS FROM MIDDLE FORK EEL RIVER



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RUNOFF AND IMPORTS FROM MIDDLE FORK EEL RIVER

PLATE 4 . . . Deleted

PLATE 5 . . . Deleted

PLATE 6

ALTERNATIVE EXPORT CONVEYANCE FACILITIES

English Ridge Reservoir to Monticello via Clear Lake

This plate indicates to reconnaissance standards the cost of conveying varying amounts of water from English Ridge Reservoir on the upper main stem Eel River to Lake Berryessa on Putah Creek.

The basic conveyance facilities required would be the Garrett Tunnel, which would divert Eel River water into the Clear Lake drainage basin, and Soda Creek Tunnel which would divert water from Clear Lake into the Lake Berryessa drainage area.

The conveyance system cost versus capacity relationship varies with the elevation selected for the Garrett Tunnel inlet and also with the normal water surface elevation of Lake Berryessa. Power recovery facilities could be installed at the locations indicated on Plate No. 6. With the inlet of Garrett Tunnel at elevation 1,600 feet, the Hunter Point Forebay was considered to have a normal water surface elevation of 1,562 feet, and the powerplant design head would be approximately 210 feet. With the tunnel inlet at 1,500 feet, the Hunter Point forebay was considered to have a normal water surface elevation of 1,500 feet, and the powerplant design head would be approximately 150 feet. If Lake Berryessa is to be enlarged to a normal water surface elevation of 800 feet, the Noyes and Snell power recovery facility sites would be inundated; however, the Jerusalem powerplant design head could be increased from approximately 140 feet to 240 feet by excavating a tailwater channel to elevation 800 feet.

In this investigation, it was assumed that the yield from the Eel River would be delivered on a firm annual basis. The monthly quantities of delivered water could be constant or varied as desired to meet a power demand schedule. The following power demand schedule was used to size and evaluate the proposed power facilities:

Month	KWH/KW	Percent
Oct.	200	7,605
Nov.	170	6,464
Dec.	180	6,844
Jan.	160	6,084
Feb.	140	5,323
March	220	8,365

Month	KWH/KW	Percent
April	190	7,224
May	200	7,605
June	260	9,886
July	330	12,547
Aug.	340	12,928
Sept.	240	9,125
Totals	2,630	100,000

Plant Capacity Factor = 30%

Another criterion used in this investigation was that Clear Lake, which would act as an afterbay for the Hunter Point power facilities, would not fluctuate more than one foot in water surface elevation as the result of power releases.

The power revenue data are based on the dependable capacity salable at $24.40 per kilowatt and the hydroelectric energy salable at $.003 per kilowatt hour at the plant. Revenue from the sale of potential secondary energy has not been included in these data.

Description of Charts

Chart A: Garrett Tunnel

Cost estimates were prepared of Garrett Tunnel, with the inlet elevation of 1,500 feet, by the Northern Branch Design Unit. The tunnel rock condition was obtained from the Department of Water Resources' geology report of September 1957. The estimates were prepared of a concrete-lined circular tunnel with a length of 12.2 miles and diameters of 10, 15, 20, and 25 feet.

The tunnel capacity-diameter relationship was based on gravity flow conditions with 50 feet of fall and was computed as follows:

$$\text{Capacity in c.f.s.} = \frac{.463}{N} S^{.5} \; D^{2.67}$$

$$= \frac{.463}{.014} \left(\frac{50}{64200}\right)^{.5} D^{2.67}$$

$$= 0.924 \; D^{2.67}$$

$$\text{Capacity in AF/Yr} = 724 \times 0.924 \; D^{2.67}$$

$$= 669 \; D^{2.67}$$

Cost estimates were also prepared of Garrett Tunnel, with the inlet at elevation 1,600 feet and a length of 48,200 feet, by the North Coastal Planning Unit. The estimates were made at tunnel diameters of 10, 15, 20, and 25 feet.

The tunnel capacity-diameter relationship, based on 50 feet of total available head, was resolved to be as follows:

$$\text{Capacity in c.f.s.} = 1.06 \; D^{2.67}$$

$$\text{Capacity in AF/Yr} = 767 \; D^{2.67}$$

<u>CHART B</u>: Hunter Point Power Facilities (Des. H = 150 feet)1/

These data are applicable when the Garrett Tunnel inlet is at elevation 1,500 feet. In most instances the powerplant dependable capacity was based on the Garrett Tunnel having a diameter greater than the minimum requirement. This resulted in increasing the dependable capacity of the Hunter Point powerplant. The incremental cost of the Garrett Tunnel due to the installation of power facilities at Hunter Point is included in these data.

The costs of the Hunter Point Forebay powerplant and tailwater channel were estimated by the North Coastal Planning Unit.

These facilities would be located on Middle Creek at stream bed elevation 1,405 feet.

<u>CHART C</u>: Hunter Point Power Facilities (Des. H = 210 feet)1/

These data are applicable when the Garrett Tunnel inlet is at elevation 1,600 feet. In most instances the powerplant dependable capacity was based on the Garrett Tunnel having a diameter greater than the minimum requirement. This resulted in increasing the dependable capacity of the Hunter Point powerplant. The incremental cost of the Garrett Tunnel, due to the installation of power facilities at Hunter Point, is included in these data.

The cost of the Hunter Point forebay was estimated by the Northern Branch Design Unit. The costs of the powerplant and tailwater channel were estimated by the North Coastal Planning Unit.

1/ Subsequent to the preparation of Plate No. 6, the name of this possible reservoir and powerhouse has been changed from Hunter Point to Pitney Ridge, to be consistent with other agencies.

CHART D: Soda Creek Tunnel

Cost estimates of the Soda Creek Tunnel with diameters of 9, 12, 16, and 21 feet were prepared by the North Coastal Planning Unit, using Department of Water Resources' Bulletin No. 78, Appendix C, estimating procedures. The round concrete-lined tunnel would have a length of 10,700 feet, with the invert elevation of the inlet at 1,320 feet.

A geologic office report based on a cursory study of the California Division of Mines' geologic mapping was used to make an estimate of the expected tunneling conditions.

The tunnel capacity-diameter relationship was based on gravity flow conditions with 15 feet of fall. With the tunnel flowing at a continuous rate throughout the year, its maximum capability was resolved to be as follows:

$$\text{Capacity in c.f.s.} = 1.26\ D^{2.67}$$
$$\text{Capacity in AF/Yr} = 913\ D^{2.67}$$

CHART E: Stienhart Power Facilities

The cost estimate for Stienhart Dam and Reservoir with a gross capacity of 100,000 acre-feet was prepared by the Northern Branch Design Unit. The costs of the remaining power facilities were estimated by the North Coastal Planning Unit. In most instances the powerplant dependable capacity was based on the Soda Creek Tunnel having a diameter greater than the minimum requirement. This reduced the forebay drawdown and resulted in increasing the dependable capacity of the powerplant. The incremental cost of the Soda Creek Tunnel, due to the installation of power facilities at Stienhart, is included in these data.

These facilities would be located on Soda Creek at stream bed elevation 1,045 feet.

CHART F: Jerusalem Power Facilities (Des. H = 240 feet)

These data are applicable when water is to be conveyed to an enlarged Monticello Reservoir. The stream bed elevation at this site on Soda Creek is 900 feet, and these data include the cost of excavating a tailwater channel to the proposed reservoir water surface elevation of 800 feet at Monticello.

The dam and reservoir cost estimate was prepared by the Northern Branch Design Unit, and the costs of the remaining facilities were estimated by the North Coastal Planning Unit.

CHART G: Jerusalem Power Facilities (Des. H = 140 feet)

These data are applicable when water is to be conveyed to the existing Monticello Reservoir. These data are based on a tailwater elevation of 900 feet.

CHART H: Noyes Power Facilities

These data are applicable when water is to be conveyed to the existing Monticello Reservoir. These facilities would be located on Putah Creek at stream bed elevation 650 feet.

The cost estimate for the dam and reservoir was prepared by the Northern Branch Design Unit, and the costs of the remaining power facilities were estimated by the North Coastal Planning Unit.

CHART I: Snell Power Facilities

These data are applicable when water is to be conveyed to the existing Monticello Reservoir. These facilities would be located on Putah Creek at the normal pool elevation (440 feet) of Lake Berryessa.

The cost estimate for the dam and reservoir was prepared by the Northern Branch, and the costs of the remaining power facilities were estimated by the North Coastal Planning Unit.

CHART J: Export Conveyance System, Capital Cost-Capacity Data

These data were developed from the previously described charts and indicate the total capital cost of the conveyance system between English Ridge Reservoir and Monticello Reservoir. Sudden increases in the cost curves occur at the capacities at which various power facilities become feasible and would reduce the net annual cost of the project.

CHART K: Export Conveyance System, Capital Cost-Capacity Data

These data were developed as described for Chart "J" for the English Ridge-Monticello Reservoir conveyance system and are applicable when the inlet elevation of Garrett Tunnel is at 1,600 feet.

CHART L: Annual Unit Cost of Conveyance System

These data were developed from the previously described charts and can be used to determine the effect of the net annual cost of the conveyance system on the unit cost of water delivered to Monticello Reservoir under various circumstances. They indicate that when relatively large quantities of water are being conveyed, the annual revenue from the installed power facilities exceeds the total annual cost of the entire conveyance system. The cost of water delivered to the existing Lake Berryessa (N.W.S. 440 feet) would be less than that delivered to the proposed enlarged Monticello Reservoir (N.W.S. 800 feet) when the Noyes and Snell power recovery facilities are feasible.

CHART D
CREEK TUNNEL
LENGTH 2.0 MILES

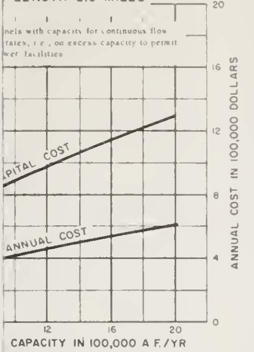


CHART E
STIENHART POWER FACILITIES
APPROX DESIGN HEAD = 270 FEET

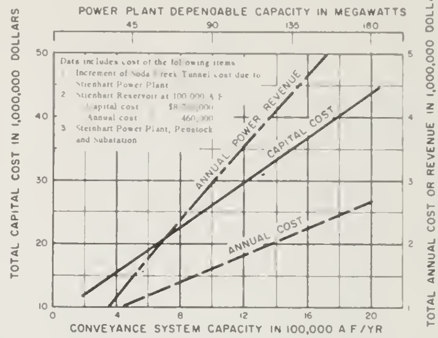


CHART H
POWER FACILITIES
ESIGN HEAD = 250 FEET

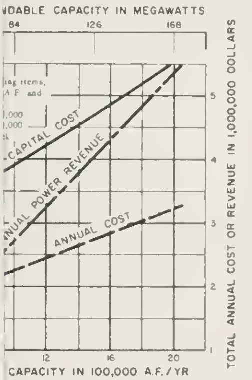


CHART I
SNELL POWER FACILITIES
APPROX DESIGN HEAD = 210 FEET

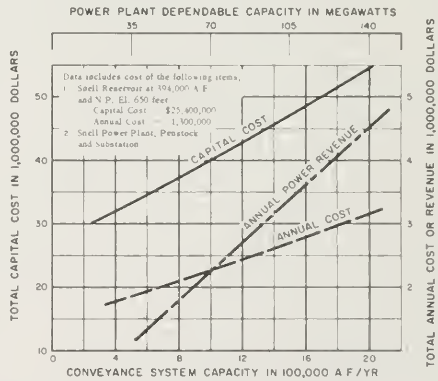
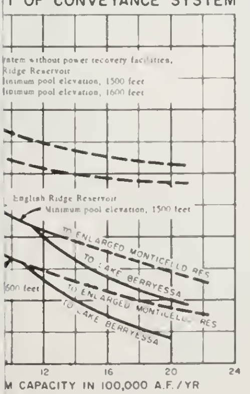


CHART L
T OF CONVEYANCE SYSTEM



Note

All estimates of capital costs include allowances of 15 percent for contingencies and 15 percent for engineering and project administration. Estimates of equivalent annual cost include annual charges for operation, maintenance and replacement and a 50 year capital recovery period at 4.0 percent interest.

The annual value of hydroelectric power is considered to consist of two components, capacity and energy

1. Dependable capacity per kilowatt year $[illegible]
2. [illegible]eable energy per kilowatt hour [illegible] mills

These data do not include consideration of the re-regulatory and additional power development functions which could be provided by the existing or possible enlarged Monticello Reservoir. That information is summarized on Plate No. [illegible] of this series.

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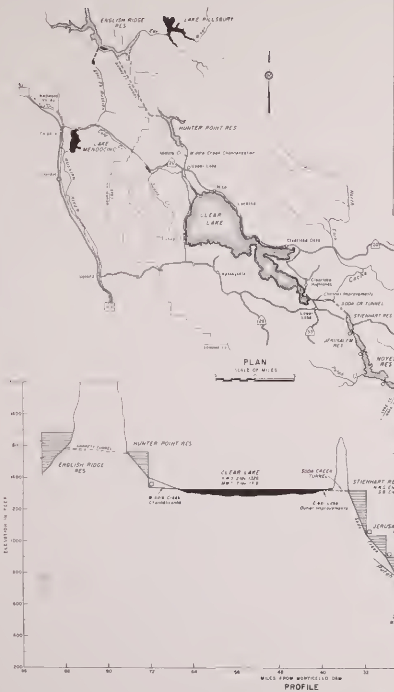

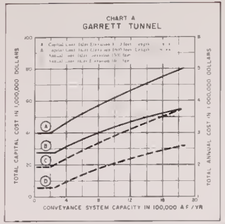

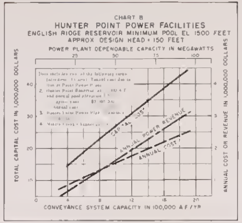

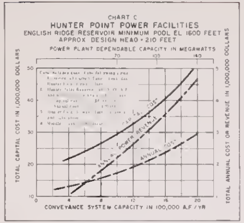

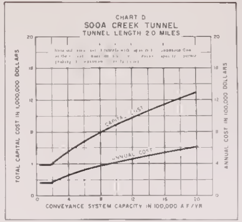

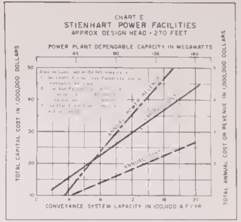

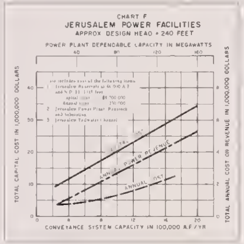

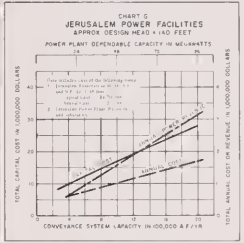

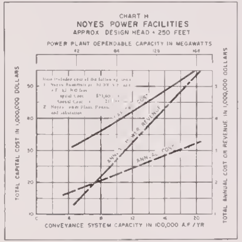

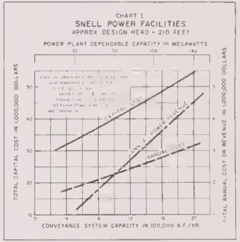

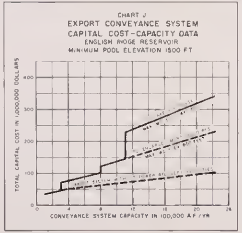

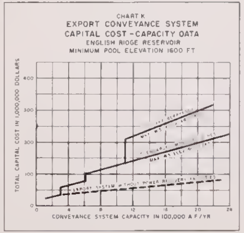

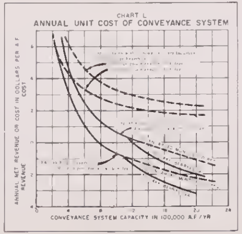

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EXPORT FROM ENGLISH RIDGE RESERVOIR VIA CLEAR LAKE TO LAKE BERRYESSA

PLATE 6A

ALTERNATIVE EXPORT CONVEYANCE FACILITIES -
ENGLISH RIDGE RESERVOIR TO MONTICELLO RESERVOIR

This plate indicates, to reconnaissance standards, the cost of conveying varying amounts of water from English Ridge Reservoir on the upper main stem Eel River to Lake Berryessa on Putah Creek.

The conveyance system presented on Plate 6A is very similar to that shown on Plate 6. The major differences are:

1. A conveyance system with the inlet at elevation 1,400 feet is included.

2. The Hunter Point Reservoir and power facilities are not included. This would facilitate a coordinated operation between English Ridge Reservoir and Clear Lake.

3. The Soda Creek Tunnel would be sized to convey "peak" power diversions and Clear Lake flood flows.

4. Stienhart Reservoir would have a normal water surface elevation of 1,300 feet with no drawdown.

The basic conveyance facilities required would be the Garrett Tunnel, which would divert Eel River water into the Clear Lake drainage basin, and the Soda Creek Tunnel which would divert water from Clear Lake into the Lake Berryessa drainage area.

The conveyance system cost versus capacity relationship varies with the elevation selected for the Garrett Tunnel inlet and also with the normal water surface elevation of Lake Berryessa. Power recovery facilities could be installed as desired at locations indicated on Plate 6A. Although, if Lake Berryessa is enlarged to a normal water surface elevation of 760 feet, the Noyes and Snell power recovery facility sites would be inundated. In this event, the Jerusalem powerplant design head would be increased from approximately 140 feet to 240 feet by excavating a tailwater channel to elevation 800 feet on Putah Creek.

In this investigation, it was assumed that the yield from the Eel River would be delivered on a firm annual basis. The monthly quantities of delivered water could be constant or varied as desired to meet a power demand schedule. The following power demand schedule was used to size and evaluate the proposed power facilities:

Month	KWH/KW	Percent
Oct.	200	7.605
Nov.	170	6.464
Dec.	180	6.844
Jan.	160	6.084
Feb.	140	5.323
Mar.	220	8.365
Apr.	190	7.224
May	200	7.605
June	260	9.886
July	330	12.547
Aug.	340	12.928
Sept.	240	9.125
TOTAL	2,630	100.000

Plant Capacity Factor = 30%

Garrett Tunnel was sized for uniform flow conditions with English Ridge Reservoir at its minimum pool elevation. Releases from English Ridge Reservoir would be made as necessary to maintain Clear Lake at the water surface elevation desired. The Soda Creek Tunnel was sized to convey the "peaking" flows for the proposed power facilities on Soda Creek and Putah Creek. Therefore, most flood flows from the Clear Lake drainage basin could be conveyed through the Soda Creek tunnel and stored in Lake Berryessa.

The power revenue data are based on the dependable capacity salable at $24.40 per kilowatt and the hydroelectric energy salable at $0.003 per kilowatt-hour at the plant. Revenue from the sale of potential secondary energy has not been included in these data.

The proposed powerplants on Soda Creek and Putah Creek would operate under a constant head, and the efficiency of the plants was assumed to be 85 percent.

Description of Charts

CHART A: Garrett Tunnel - Capital Cost

CHART B: Garrett Tunnel - Annual Cost

Cost estimates were prepared for Garrett Tunnel, with the inlet at elevation 1500 feet, by the Northern Branch Design Unit. The tunnel rock conditions were obtained from the Department of Water Resources' geology report of September 1957. The estimates were prepared for a concrete-lined circular tunnel with a length of 12.2 miles and diameters of 10, 15, 20, and 25 feet.

The tunnel capacity-diameter relationship was based on gravity flow conditions with 50 feet of fall and was resolved as follows:

Capacity in c.f.s.	$0.924\ D^{2.67}$
Capacity in AF/Yr	$669\ D^{2.67}$

Cost estimates were also prepared for Garrett Tunnel with the inlet at elevations of 1,400 and 1,600 feet and respective lengths of 100,700 feet and 48,200 feet by the North Coastal Planning Unit. The estimates were made for tunnel diameters of 10, 15, 20, and 25 feet.

The tunnel capacity-diameter relationships, based on 50 feet of total available head were as follows:

	1,400 feet	1,600 feet
Capacity in c.f.s.	$0.737\ D^{2.67}$	$1.064\ D^{2.67}$
Capacity in AF/Yr	$534\ D^{2.67}$	$767\ D^{2.67}$

CHART C: Soda Creek Tunnel

Cost estimates of the Soda Creek Tunnel with diameters of 9, 12, 16, and 21 feet were prepared by the North Coastal Planning Unit, using Department of Water Resources Bulletin No. 78, Appendix C, estimating procedures. The round concrete-lined tunnel would have a length of 10,700 feet, with the water surface elevation at the inlet of 1,320 feet.

The tunnel capacity-diameter relationship was based on gravity flow conditions with 15 feet of fall. With the tunnel flow based on a power schedule, the maximum capability was as follows:

Capacity in c.f.s.	$1.240\ D^{2.67}$
Capacity in AF/Yr	$269\ D^{2.67}$

Capacity Factor = 30%

CHART D: Stienhart Power Facilities

The cost estimate for Stienhart Dam and Reservoir at a gross capacity of 80,000 acre-feet, and the power facilities, were estimated by the North Coastal Planning Unit. The normal water surface elevation of Stienhart Reservoir would be 1,300 feet.

These facilities would be located on Soda Creek at a streambed elevation of 1,045 feet.

CHART E: Jerusalem Power Facilities (design head = 240 feet)

These data are applicable when water is to be conveyed to Lake Berryessa, whether existing or enlarged, in amounts up to 1,000,000 acre-feet/year, or to enlarged Monticello Reservoir only when delivering amounts greater than 1,000,000 acre-feet/year.

The streambed elevation at this site on Soda Creek is 900 feet, and these data include the cost of excavating a tailwater channel with a water surface elevation of 800 feet.

The dam and reservoir cost estimate was prepared by the Northern Branch Design Unit, and the costs of the power facilities were estimated by the North Coastal Planning Unit.

CHART F: Jerusalem Power Facilities (design head = 140 feet)

These data are applicable when water is to be conveyed to existing Lake Berryessa in amounts over 1,000,000 AF/year. These data are based on a tailwater elevation of 900 feet.

CHART G: Noyes Power Facilities

These data are applicable when water is to be conveyed to the existing Lake Berryessa in amounts over 1,000,000 AF/year. These facilities would be located on Putah Creek at streambed elevation 650 feet.

The cost estimates for the dam and reservoir were prepared by the Northern Branch Design Unit, and the costs of the remaining power facilities were estimated by the North Coastal Planning Unit.

CHART H: Snell Power Facilities

These data are applicable when water is to be conveyed to the existing Lake Berryessa in amounts over 1,000,000 AF/year. These facilities would be located on Putah Creek at streambed elevation 360 feet.

The cost estimate for the dam and reservoir was prepared by the Northern Branch Design Unit, and the costs of the remaining power facilities were estimated by the North Coastal Planning Unit.

CHART I, J, AND K: Export Conveyance System

Capital Cost - Capacity Data

Chart I: English Ridge Reservoir with minimum pool elevation of 1,400 feet, Garrett Tunnel inlet elevation 1,400 feet.

Chart J: English Ridge Reservoir with minimum pool elevation of 1,500 feet, Garrett Tunnel inlet elevation 1,500 feet.

Chart K: English Ridge Reservoir with minimum pool elevation of 1,500 feet, Garrett Tunnel inlet elevation 1,600 feet.

These data were developed from the previously described charts and indicate the total capital cost of the conveyance system between English Ridge Reservoir and Monticello Reservoir. Sudden increases in the cost curves occur at the capacities at which various power facilities become feasible and would reduce the net annual cost of the project.

CHART L: Annual Unit Cost of Conveyance System

These data were developed from the previously described charts and can be used to determine the effect of the net annual cost of the conveyance system on the unit cost of water delivered to Monticello Reservoir under various circumstances. They indicate that when relatively large quantities of water are being conveyed, the annual revenue from the installed power facilities exceeds the total annual cost of the entire conveyance system. The cost of water delivered to the existing Lake Berryessa (N.W.S. 440 feet) may be less than when delivered to the proposed enlarged Monticello Reservoir (N.W.S. 760 feet) due to the Noyes and Snell power recovery facilities.

CHART D
POWER FACILITIES
IGN HEAD = 250 FEET

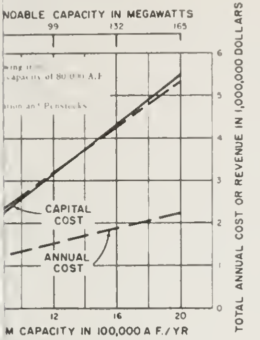


CHART E
JERUSALEM POWER FACILITIES
APPROX. DESIGN HEAD = 240 FEET

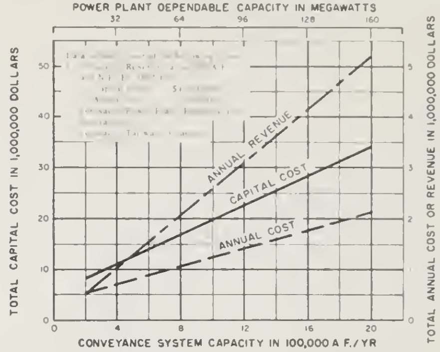


CHART H
POWER FACILITIES
ESIGN HEAD = 210 FEET

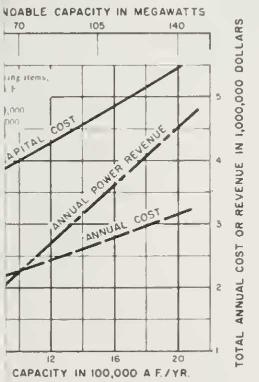


CHART I
EXPORT CONVEYANCE SYSTEM
CAPITAL COST-CAPACITY DATA
ENGLISH RIDGE RESERVOIR
MINIMUM POOL ELEVATION 1400 FT.

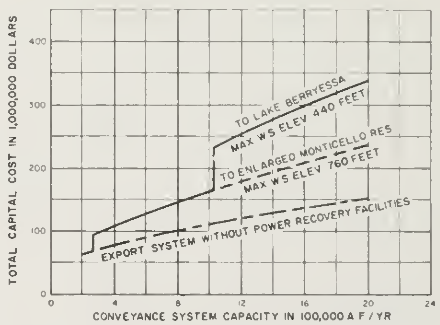
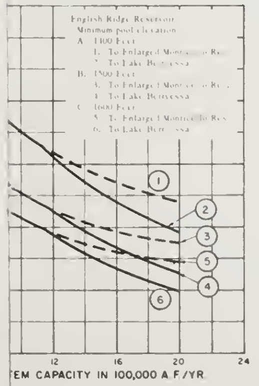


CHART L
ST OF CONVEYANCE SYSTEM



Note

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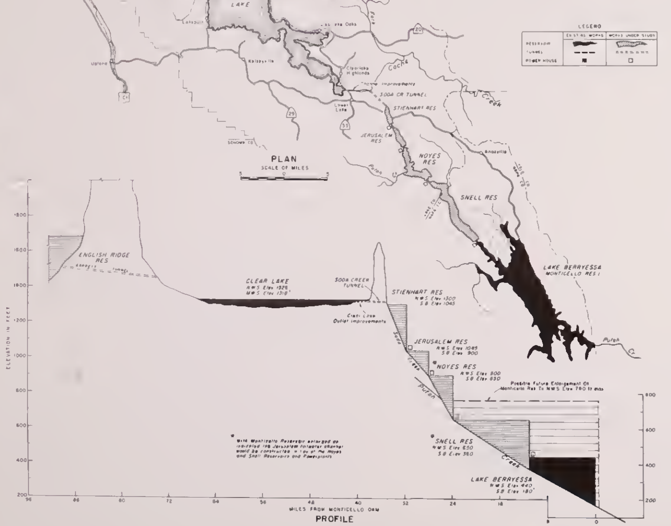

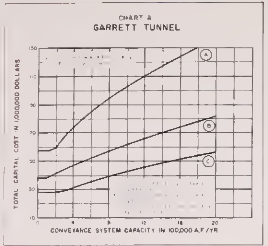

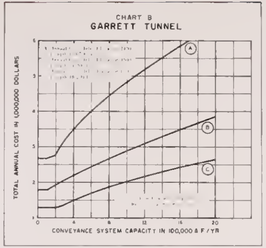

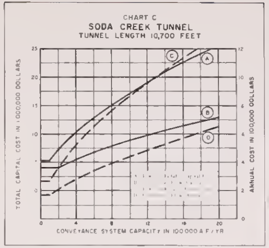

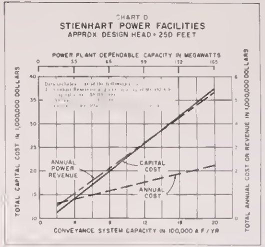

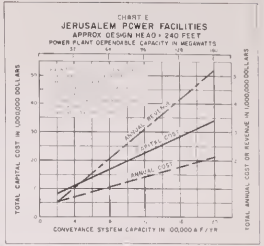

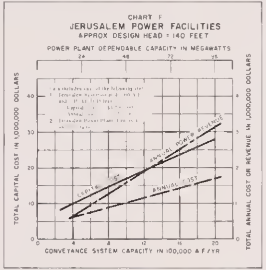

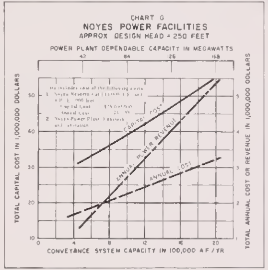

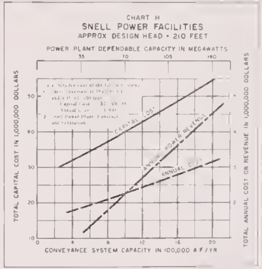

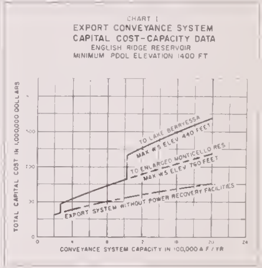

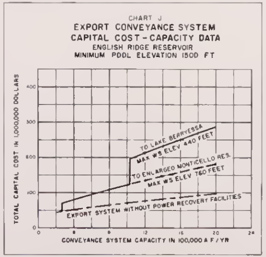

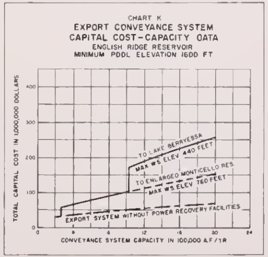

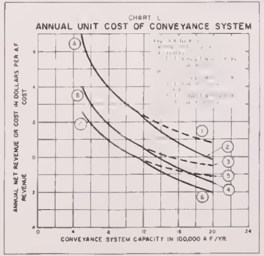

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PLATE 7

ENLARGED MONTICELLO PUMPED-STORAGE PROJECT

Diversion from the Sacramento River

The purpose of this analysis was to evaluate, to reconnaissance standards, the new water yield accomplishments, pumped-storage power potential, and associated costs when surplus flows of the Sacramento River are pumped into an enlarged Monticello Reservoir. The water would be released from the reservoir in coordination with Sacramento River flows to provide firm yield at the intakes of the pumping plants near Tracy for export to the San Joaquin Valley.

In this reconnaissance analysis, consideration was not given to certain other potential project purposes such as improved flood control and recreation. These items are believed to be of minor significance only, due to the existing Monticello Reservoir which has a storage capacity of 1,600,000 acre-feet.

The basic facilities of the potential development are as follows:

1. Monticello Reservoir enlargement.
2. Sacramento River diversion facilities.
3. Putah Creek channelizing.
4. Putah Creek pumping plants (2).
5. Monticello Afterbay, normal water surface elevation 2.5 feet.
6. Monticello Reservoir pumping plant.
7. Pumping plant at the Sacramento ship channel for exporting water to the Sacramento River.

Quite obviously, it is difficult to evalute this project proposal, even to a moderately intensive degree under this reconnaissance analysis, due to the numerous and complex alternatives and variables which have significant effect upon the yield-cost-power relationships. These important variables are as follows:

1. Storage capacity of Monticello Reservoir.
2. Conveyance capacity of import facilities.
3. Pumping plant operation, i.e., continuous or off-peak schedule.
4. Pumping units, i.e., conventional or reversible pump-turbine type.

5. Installed capacity of reversible pump-turbine facilities if operated to generate energy and firm capacity. This would be accomplished by making power releases into the afterbay during on-peak hours and pumping back into the reservoir, as required, during off-peak hours.

6. Sacramento River surplus flows. Various studies have been performed previously by the Department of Water Resources and the U. S. Bureau of Reclamation to determine the surplus flows of the river when projected for conditions that would exist in 1990.

A 40-year operation study performed for many capacities of the alternative facilities listed above is necessary for a more detailed appraisal of this project. This would probably be accomplished best by means of an electronic computer, using a program similar to that for the San Luis pump-turbine operation study.

The proposed site for the new Monticello Dam is approximately one mile downstream of the existing dam. There are several reasons for selecting this site:

1. It is an excellent damsite as reflected by the reservoir cost-capacity data shown on Chart E.

2. Construction of the new dam would not require drainage of the existing Lake Berruessa and would not interfere with the operation of the existing Solano Project. The downstream water requirements would be supplied through a steel conveyance pipe from the existing reservoir.

3. Water stored in the existing reservoir at the time of completion of the new dam would have a special value to the pumped-storage project. A relatively long period may be required to fill the enlarged reservoir, initially, to a level which would allow reasonably safe operation of the project. The cost of interest and project operation during this filling period would be reduced in direct proportion to the amount of water existing in Lake Berryessa.

All references to project yield refer to yield at the Sacramento River Delta. It was assumed that there would be no surplus capacity remaining in San Luis Reservoir, and therefore the yield would be developed on the same schedule as that proposed to be delivered to the San Joaquin

Valley from the State Water Facilities at San Luis. When the anticipated project operation is based on historical runoff, deficiencies of 26.4 percent of the annual yield would be taken in the calendar years corresponding to 1924, 1931, and 1933.

This particular analysis has again indicated the need of reliable and consistent estimates of the Sacramento River surplus flows. The "surpluses" used in this analysis were those computed in the U. S. Bureau of Reclamation-Department of Water Resources' joint study of September 29, 1960. A brief analysis of this project using the "State No. 2" estimates of surplus flow indicated little change in project yield, however.

It should be noted that the project yield-storage and yield-cost relationships shown on this plate may not be accurate, if this project is operated independently of other major projects which supply water to the Delta. If this project is operated independently and sized to develop relatively large yields, the carryover period of 1917-1950 would become critical, in which case the water yields would be reduced below that indicated on this plate for a given project.

Description of Data

CHART A: Elevation-Area-Capacity Data - Monticello Reservoir (Enlarged)

These data were developed for the proposed reservoir which would be created by a dam at streambed elevation 180 feet on Putah Creek (Sec. 28, T8N, R2W, MDB&M).

The water surface elevation versus area data were determined by planimetering the U. S. G ological Survey quadrangles: Capay, Mt. Vaca, St. Helena, and Morgan Valley; scale 1:62,500; at contour lines which were plotted at intervals of 50 and 80 feet.

CHART B: Elevation-Area-Capacity Data - Monticello Afterbay Reservoir

These data were developed for the proposed reservoir which would be created by a dam at streambed elevation 120 feet on Putah Creek (Southeast 1/4, Sec. 31, T8N, R1W).

The water surface elevation versus area data were determined by planimetering the U. S. Geological Survey quadrangles: Capay and Mt. Vaca; scale 1:62,500; at contour lines which were plotted at intervals of 50 feet.

CHART C: Reservoir Release and Project Yield Relationship

These data indicate the average quantity of water that would be released annually from storage in coordination with Sacramento River surplus flows to provide a given yield at the Delta. The monthly quantities of surplus flow were subtracted from the monthly demand to determine the necessary release from storage. It was assumed that the Sacramento River flows within months would be uniform. These data are applicable to any reservoir such as enlarged Monticello or the Glenn Complex, when operated to regulate imported water and develop a firm yield at the Delta.

CHART D: Reservoir Yield-Capacity Data

These data indicate the firm yield and active storage relationship of the project with the diversion system from the Sacramento River at varying capacity.

It was assumed that the demand schedule at the Delta would be the same as that projected for San Luis Reservoir based on 1990 conditions.

Month	Normal Year (In Percent)	Deficient Year 1924, 1931, 1933 (In Percent)
January	3.6	3.6
February	3.4	3.4
March	6.2	6.2
April	7.5	5.4
May	10.2	6.9
June	12.5	8.1
July	15.8	10.0
August	15.4	9.7
September	11.3	7.5
October	6.1	4.8
November	4.3	4.3
December	3.7	3.7
TOTAL	100.0	73.6

The computed yield would be after evaporation losses and after sustaining the federal Solano Project firm yield of 247,000 acre-feet per year.

CHART E: Reservoir Cost-Capacity Data

These data were developed from cost estimates of enlarged Monticello Reservoir which were prepared by the Northern Branch Design Unit. The costs were determined for an earth- and rockfill dam at normal water surface elevations of 550, 700, and 800 feet and include the following items:

1. Monticello Dam, spillway, and outlet works.

2. Reservoir right of way, clearing, and highway relocation. The land acquisition cost was estimated for the year 1980 by the Division of Right of Way Acquisition and the Northern Branch Economics Unit.

3. A 7.5-foot diameter steel conveyance pipe connecting the outlet works of the existing dam to a cut and cover conduit built at streambed level through the proposed dam.

CHART F: Diversion Facilities, Cost-Capacity Data

These data were developed from cost estimates prepared by the North Coastal Area Investigations Unit and reviewed by the Northern Branch Design Unit.

The conveyance channel up Putah Creek would be cut to a flat bottom gradient since it would convey water in two directions. The channel would have an unlined, trapezoidal section with side slopes at 2:1. The lower reach from the Sacramento ship channel to the Davis pump lift would have a length of 64,680 feet and a minimum water depth of 10 feet. The upper reach from the Davis Reservoir to Monticello Afterbay would have a length of 71,700 feet and a minimum water depth of 15 feet. There would be sufficient freeboard to allow an extra 5 feet of depth at either end of each reach. This would provide an average water surface slope of .000077 in the lower reach and .00007 in the upper reach. The channel base width would vary with its design capacity. It was determined that for design capacities in either direction of 3,000, 5,000, and 8,000 cfs, the base width would be 95, 160, and 260 feet, respectively, in the lower reach, and 45, 80, and 135 feet, respectively, in the upper reach. The velocity of flow in each reach would be approximately 3 feet per second. More study should be given to the optimum dimensions of this channel after its desired design capacity is determined.

The data in Chart F are based on the following cost estimates of the Putah Creek conveyance facilities.

Item	3,000 cfs	5,000 cfs	8,000 cfs
Sacramento River Diversion Facilities	$ 1,245,000	$ 1,595,000	$ 1,945,000
Ship channel siphon (L=1,500')	2,100,000 (D=15')	2,730,000 (D=18')	3,360,000 (D-21')
Putah Creek Channel (L=26 miles)	11,650,000	16,000,000	22,500,000
Davis pumping plant (H=90')	7,000,000	11,400,000	17,710,000
Davis Dam and drop structure	1,540,000	2,410,000	3,770,000
Putah Creek levee near Davis	1,365,000	1,365,000	1,365,000
Afterbay pumping plant (H=120')	7,800,000	12,800,000	20,060,000
Monticello Afterbay (NWS 215')	5,280,000	5,280,000	5,280,000
Extension of Putah South Canal (L=4,500')	510,000	510,000	510,000
Bridges and road relocation	3,000,000	3,360,000	3,850,000
	$41,490,000	$57,450,000	$80,350,000

The annual cost data include repayment of capital cost plus interest and annual operation, maintenance, and replacement costs. The pumping plant annual electrical charges are not included in these data.

CHART G: Diversion Facilities, Cost-Yield Relationship

These data indicate the total annual cost of the Putah Creek conveyance facilities at a capacity of 4,000 cfs, when the Monticello Pumped Storage Project is sized to develop a given yield at the Sacramento Delta. The data in Chart C were used to determine the average annual delivery into Monticello Reservoir, which would be required to sustain a given yield. The average annual pumping energy requirement was based on pumping the average amount which would be released from storage, plus 100,000 acre-feet to allow for annual evaporation losses. For example, when a firm yield of 1,600,000 acre-feet per year is to be developed at the Delta, the average delivery into Monticello Reservoir would be approximately 1,230,000 acre-feet per year.

It was assumed that the Putah Creek pumping plants would be operated on-peak and would not be of the reversible type for power generation.

CHART H: Water Yield-Electrical Capacity Relationship

These data indicate the proposed generating capacity and the installed pumping capacity of the reservoir pump-turbine plant when the project is sized to develop a given yield. Power releases would be made into the afterbay on a typical power schedule even though supplemental water might not be required at the Delta. The power schedule used in this investigation is based on a plant capacity factor of 30 percent and is as follows:

Month	KWH/KW	Percent
January	160	6.084
February	140	5.323
March	220	8.365
April	190	7.224
May	200	7.605
June	260	9.886
July	330	12.547
August	340	12.928
September	240	9.125
October	200	7.605
November	170	6.464
December	180	6.844
TOTAL	2,630	100.000

It was assumed that the afterbay would operate between W.S. elevations 185 and 215 feet with an active capacity of 37,000 acre-feet.

The gross capacity of Monticello Reservoir would be such that when a given yield is to be developed, the required amount of active reservoir capacity would be provided within the operating limits of the pump-turbine plant. It was considered that the pump-turbine minimum operating head should be at least 56 percent of its maximum operating head. For example, Monticello Reservoir at a N.W.S. elevation of 750 feet would have a gross capacity of 13,300,000 acre-feet. The maximum pumping head would be 560 feet and the minimum permissible head would be 313 feet. Thus the minimum W.S. elevation is established at 505 feet, and the reservoir would have an active capacity of 10,000,000 acre feet. As shown on Chart D, the project yield with a 4,000 cfs import system and 10,000,000 acre-feet of active storage is 1,650,000 acre-feet per year.

The operating head on the pumping plant was reduced by 15 feet to obtain the operating head on the reversible units when generating.

The capacity of the generating units could not be so great that the afterbay could not store the power releases made during on-peak hours in addition to the water imported from the Sacramento River during this period. In a month such as March, power generation at the pump-turbine plant's dependable capacity, would be sustained during 9 hours of each weekday. Surplus Sacramento River water would be pumped into the afterbay at 4,000 cfs, 24 hours per day. The pump-turbine plant would pump water from the afterbay into Monticello Reservoir and maintain the afterbay within its storage limits, on the following off-peak schedule:

Monday through Friday	9 hours per day
Saturday	15 hours
Sunday	24 hours

It was found that the afterbay storage requirement could also become critical during the month of August, when the generating units must sustain their dependable capacity for 14.8 hours per day. The afterbay must store the difference between the quantities of inflow due to the power releases from Monticello Reservoir and the outflow due to the Delta demand. Any water remaining in the afterbay during off-peak hours which would not be needed at the Delta would be pumped back into Monticello Reservoir.

The data in this chart also indicate the annual revenue for the sale of dependable capacity at load center.

CHART I: Water Yield-Electrical Energy Relationship

These data indicate the average annual energy requirements of the reservoir pumping units and the amount of energy recovered annually by the reversible units when the project is sized to develop a given yield.

The amount of energy generated annually was computed by multiplying the dependable capacity (shown on Chart H) by 2,630 hours.

In connection with the analysis of this potential pumped-storage project, reference is made to the "Symposium on Pumped-Storage" published in the July 1962 "Power Division Journal, Proceedings of the American Society of Civil Engineers".

The average amount of energy required annually for pumping was considered to be 150 percent of that generated, plus the energy requirements of pumping the water imported from the Sacramento River into the reservoir. The average annual import would be the average annual irrigation release as shown in Chart C, plus 100,000 acre-feet.

These data also indicate the annual value of the energy required and recovered by the pump-turbine plant based on a rate of 3 mills per kwh. It should be noted that the value of pumping energy was actually considered to be 3.3 mills per kwh when the project annual costs were computed and shown in the concluding charts of this plate.

CHART J: Pump-Turbine Plant, Cost-Capacity Data

The data shown on this chart indicate the total cost of a pump-turbine plant at a given capacity when pumping water into Monticello Reservoir with a given N.W.S. elevation.

A typical cost-capacity curve for estimating the cost of large conventional pumping plants was prepared by the North Coastal Area Investigations Unit in August 1962. The data were based on costs of existing plants such as at Tracy and Grand Coulee. The costs of the basic plant obtained from this curve were increased by 30 percent to reflect the increased cost of a reversible pump-turbine plant.

The cost of the electrical substation was also obtained from data which were assembled by this unit in March 1961.

The estimated cost of the plant discharge pipes was based on an installed cost of 35 cents per pound. The weight of the steel pipes was computed with consideration given to the number of pipes, the optimum diameter, the length, and the wall thickness.

CHART K: Sacramento River Pumping Plant, Yield-Cost Relationship

These data indicate the capital and average annual cost of the plant which would pump the required amount of water through the ship-channel siphon and into the Sacramento River, when a given yield is to be developed at the Delta. Actually, there is very little difference between the elevations of the water surface in the proposed import-export channel and the river when it is flowing under 20,000 cfs. It was assumed in this analysis that the total dynamic head on the pumping plant would be 15 feet at all times, and the plant would be sized to convey the July delivery (15.8 percent of the total annual yield) against this head. The average annual electrical energy requirement would be that required to pump the average quantity of water released from storage annually, as shown on Chart C. For example, with a firm annual yield of 1,500,000 acre-feet developed at the Delta, the plant would be capable of pumping 3,900 cfs, it would have an installed capacity of 6,000 kilowatts and an average annual energy requirement of 18,900,000 kilowatt-hours.

CHARTS L AND M:

These data, assembled from the preceding charts, indicate the capital and annual cost versus annual yield relationship of the total pumped-storage project, with a 4,000 cfs import system from the Sacramento River. These data do not include any costs associated with filling the reservoir, initially.

CHART N:

This information summarizes the estimated capitalized cost of filling the enlarged reservoir initially to a safe operating level with a 4,000 cfs import system from the Sacramento River.

It is not likely that the full yield capability would be required from this project immediately upon construction. However, in order to compare this project with alternative projects on an equal basis, some allowance must be made for the fact that several years of operation may be required before the full yield could be developed with a reasonable degree of assurance.

A study of the Delta surpluses with 1990 conditions indicated that for the years corresponding to 1922-41, the average import when filling the reservoir, initially, from the Sacramento River would be approximately 950,000 acre-feet per year. The 50-year mean annual runoff of Putah Creek at Monticello Dam is 344,000 acre-feet.

It is difficult to define the term "initial safe operating level" since it varies with the degree of risk that one is willing to assume. This could be a critical decision, however, since the annual interest on a capital investment of $300,000,000 is approximately $12,000,000.

The data on Chart H and in the table listed below are based upon the following criteria:

A. The Solano Project delivery of 247,000 acre-feet per year would be sustained throughout the filling period.

B. The existing reservoir would contain 1,000,000 acre-feet of water at the beginning of the filling period.

C. The mean evaporation rate would be 3 feet per year.

D. The power recovery facilities would begin recycling water and develop full dependable capacity when the enlarged reservoir fills to its minimum pool level.

Yield (1,000 A.F.)	Dead Storage (1,000 A.F.)	Filling Period (Years)	Initial Safe Oper. Level (1,000 A.F.)	Total Filling Period (Years)
450	300	0	1,000	0
1,000	1,400	.5	3,000	2
1,500	2,600	1.6	4,000	3
1,650	3,300	2.5	5,000	4.2
1,840	3,900	3.0	6,000	5.25

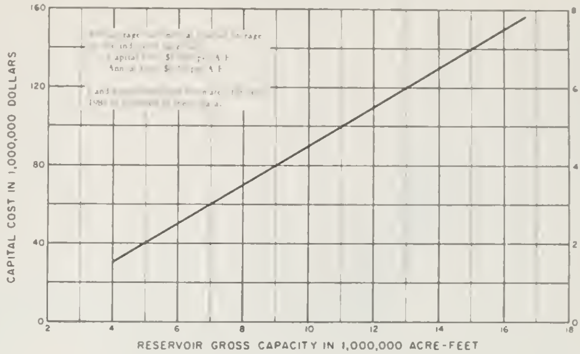
CHART O:

These data, which were developed from Charts M and H, indicate the annual unit cost of new yield developed at the Delta from the Monticello Pumped Storage Project.

SUMMARY

On the basis of this reconnaissance analysis, it is quite apparent that a "Greater Berryessa" Project exhibits considerable economic potential as a future major water conservation project in Northern California. It is recommended that consideration be given to more intensive study of this project possibility when staff time and funds permit under our forthcoming North Coastal projects investigation.

CHART E
COST-CAPACITY DATA
MONTICELLO RESERVOIR (ENLARGED)



J
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URBINE PLANT

SURFACE ELEVATION

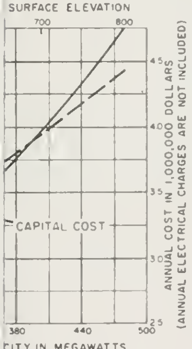
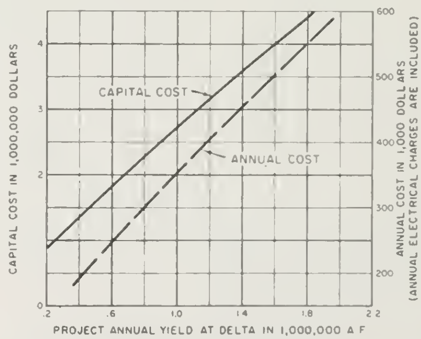
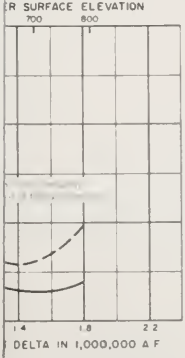


CHART K
COST-CAPACITY DATA
SACRAMENTO RIVER PUMPING PLANT
(TOTAL HD = 15 FT)



O
M EXPORTABLE YIELD
RAMENTO RIVER DELTA
O C F S CAPACITY)

R SURFACE ELEVATION



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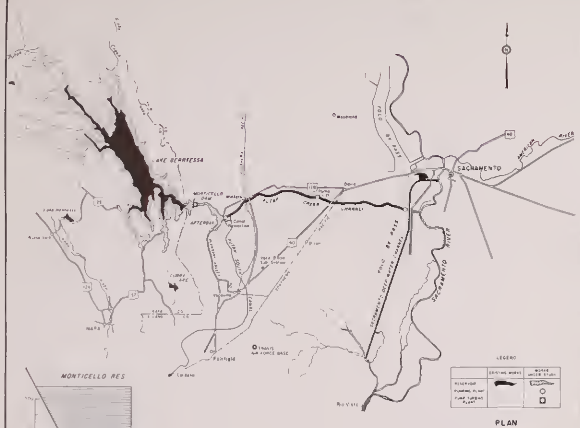

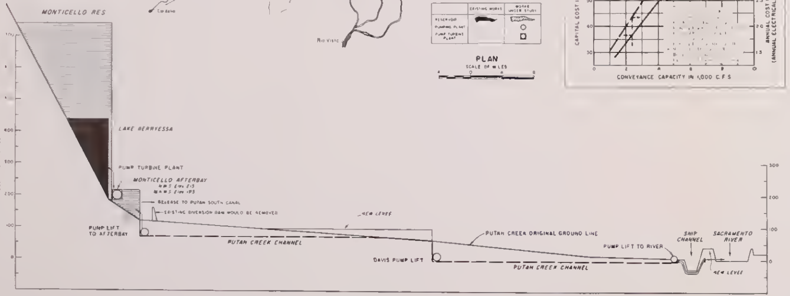

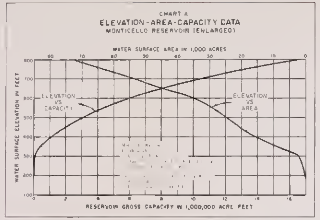

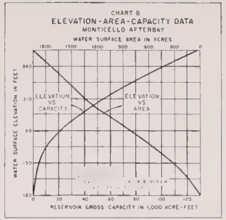

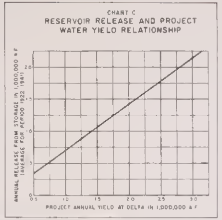

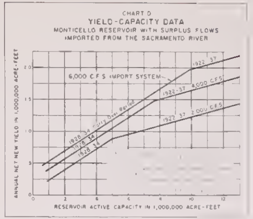

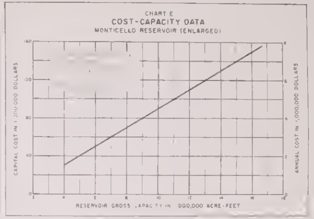

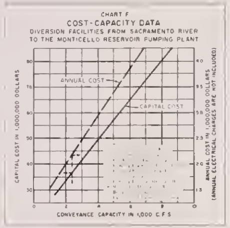

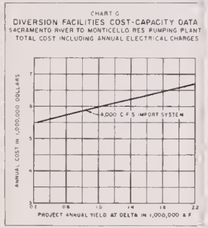

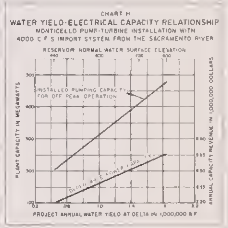

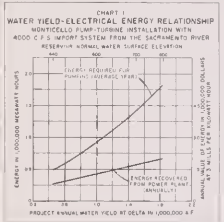

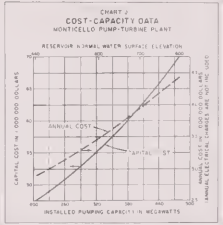

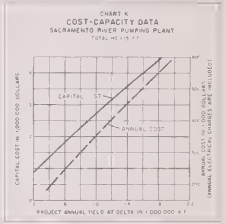

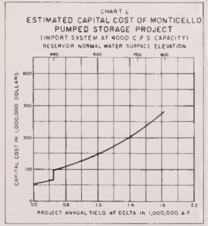

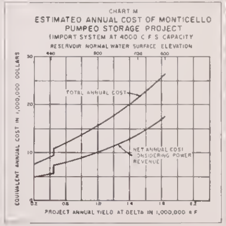

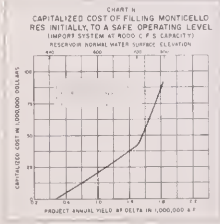

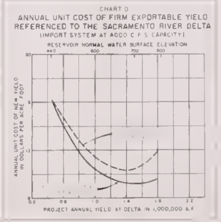

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PLATE 8
CLEAR CREEK EXPORT CONVEYANCES FACILITIES
Diversion from the Trinity River

Plate 8 presents physical data and the approximate cost of the conveyance facilities which could be used to export water from the Trinity River Basin via Clear Creek to Iron Canyon Reservoir at an elevation of 400 feet.

Studies were made for exports of 500,000 acre-feet, 1,000,000 acre-feet, 1,500,000 acre-feet, 2,000,000 acre-feet, 2,500,000 acre-feet, and 5,000,000 acre-feet.

Three methods of export were given consideration for export of Trinity River water at intake elevations of 1,500, 1,550, 1,600, and 1,650 feet via Clear Creek to Iron Canyon Reservoir at elevation 400 feet. These were: (1) by use of the smallest possible tunnel from the Trinity River to Clear Creek and diverting at a uniform rate, with continuous power generation at Whiskeytown, Kanaka, Saeltzer, and Girvan Powerplants; (2) by use of a tunnel large enough to peak through, with a power drop into Whiskeytown Reservoir, and peaking power generation at Whiskeytown, Kanaka, Saeltzer, and Girvan Powerplants; (3) by use of a tunnel large enough for the average monthly power flow during the month of August (largest month) and a forebay (Towerhouse Reservoir) at the tunnel exit which would provide the necessary storage required for peaking and thus would develop the full power potential on Clear Creek. The conclusions were that the first method would reduce the yield out of Iron Canyon and would develop only uniform power; the second would develop the maximum power head, but would require a very expensive tunnel since it would be oversized for peaking capacity and slightly longer due to a lower outlet elevation. The third method would have a smaller diameter and shorter length tunnel than the second method, but would require Towerhouse Reservoir to reregulate the Trinity River water and develop the power head. Preliminary studies indicate that the third method would be the more economical; therefore, the third method was selected in this analysis to determine the optimum size tunnel and forebay for the various Trinity River yields.

Description of Data

CHART A: Clear Creek Tunnel No. 2, Diameter-Capacity Data

These data indicate the relationships between diameter and annual conveyance capacity for the Clear Creek Tunnel No. 2, which would convey water from Helena Reservoir to Towerhouse or Whiskeytown Reservoirs on a power schedule. The tunnel diameter was computed on the assumption that it would convey 12.928 percent of the total annual delivery during one month of continuous flow, with Helena Reservoir drawn down to the tunnel inlet. Towerhouse or Whiskeytown Reservoir, as the case may be, would provide the required forebay regulation during each week.

The sharp breaks in the four curves occur at the amounts of annual delivery that make the Towerhouse power facilities become economically feasible. The increase in diameter is due to the decrease in head available for tunnel flow when Towerhouse Reservoir is constructed. This break would occur with tunnel intake elevations of 1,500, 1,550, 1,600, and 1,650 feet at export yields of 2,460,000, 1,130,000, 970,000, and 830,000 acre-feet per year, respectively, when the value of hydroelectric power is valued as indicated on Plate 8.

CHART B: Clear Creek Tunnel No. 2, Cost-Capacity Data

The sharp breaks in the four curves occur when it would be more economical to use Helena-Towerhouse Tunnel, Towerhouse Reservoir, and Towerhouse Powerplant rather than just the Helena-Towerhouse Tunnel. The increase in cost is due to the increase in diameter necessary because of the decrease in head available to the tunnel flow. This break occurs with tunnel intake elevations of 1,500, 1,550, 1,600, and 1,650 at export yields of 2,460,000, 1,130,000, 970,000, and 830,000 acre-feet per year, respectively.

Costs of Clear Creek Tunnel with intake elevations of 1,500, 1,550, 1,600, and 1,650 and outlet elevation of 1,350 were taken from cost curves prepared by the Northern Branch Design Unit to preliminary standards. These curves were extended by Trinity River division planning personnel for tunnel diameters greater than 25 feet.

CHART C: Towerhouse Reservoir - Optimum Water Surface Elevations and Forebay Storage Requirement

Optimum water surface elevations of Towerhouse Reservoir are shown for the four intake elevations at various export yields. In these reconnaissance level studies, water surface elevations were determined to the nearest 25-foot levels, and at export yields of 500,000; 1,000,000; 1,500,000; 2,000,000: 2,500,000; and 5,000,000 acre-feet per year.

These data, together with the data in Chart D indicate the storage required to store the inflow during the 57-hour weekend period that the powerplant would be shut down. These data are based upon the inflow conduit having a capacity equal to the average monthly flow of the month of greatest power generation which is August and would amount to 12.928 percent of the annual flow. This means that the tunnel would have a capacity approximately 50 percent greater than that required for uniform flow.

CHART D: Towerhouse Reservoir, Elevation-Area-Capacity Data

The area was planimetered from the USGS quadrangle of French Gulch, scale 1:62,500, with a contour inverval of 100 feet. Capacity was computed by the average end area method.

CHART E: Towerhouse Reservoir, Cost-Capacity Data

The capital cost of Towerhouse Dam and Reservoir was estimated by the Northern Branch, Design Unit, to preliminary standards for four sizes: N.P. elevation 1,350, and gross capacity of 29,000 acre-feet; N.P. elevation 1,400, and gross capacity of 68,000 acre-feet; N.P. elevation 1,500, and gross capacity of 210,000 acre-feet; and N.P. elevation 1,600, and gross capacity of 466,000 acre-feet.

The annual cost is based on repayment of the capital cost during a 50-year repayment period with interest at 4 percent compounded annually and includes the costs of operation, maintenance and general expense.

CHART F: Net Annual Value of Towerhouse Reservoir as a Forebay

The curves which show the annual value of using Towerhouse Reservoir as a regulating forebay for Trinity River export water instead of the existing Whiskeytown Reservoir, indicate that with the Clear Creek Tunnel intake elevation at 1,500 feet, Towerhouse Reservoir would pay off at an export yield of 2,460,000 acre-feet, but would be very marginal through a yield of 5,000,000 acre-feet. For intakes of 1,550, 1,600, and 1,650, Towerhouse Reservoir would pay off at export yields of 1,130,000; 970,000; and 830,000, respectively.

The annual value of using Towerhouse Reservoir instead of Whiskeytown Reservoir as a forebay for Trinity River export water would be the sum of the annual power revenue at Towerhouse Powerplant, and the annual loss of power revenue at the Whiskeytown Powerplant and the USBR's Spring Creek Powerplant, minus the annual cost of Towerhouse Dam and Powerplant, and the difference between the annual cost of a tunnel to Towerhouse Reservoir and a tunnel to Whiskeytown Reservoir.

The power revenue loss curve indicates the annual power revenue loss at Whiskeytown and Spring Creek Powerplants due to the decrease in operating level of Whiskeytown Reservoir when used as a forebay for re-regulation of Trinity River export water. These data were used in the computations for the net annual value curves as described above.

CHART G: Towerhouse Power Facilities, Capital Cost and Dependable Capacity Data

The Towerhouse Powerplant was economically sized for annual yields of 500,000, 1,000,000, 1,500,000, 2,000,000, 2,500,000, and 5,000,000 acre-feet with tunnel intake elevations on the Trinity River of 1,500, 1,550, 1,600, and 1,650 feet. This size takes into consideration Clear Creek Tunnel, Towerhouse Dam and Reservoir, and Towerhouse Powerplant. Normal pool elevations at Towerhouse Reservoir were studied at even 25-foot intervals.

The Towerhouse power facilities would not be used until export yields of 2,460,000, 1,130,000, 970,000, and 830,000 acre-feet are reached with tunnel intake elevations of 1,500, 1,550, 1,600, and 1,650, respectively.

The powerplant costs for each of the yields were estimated from curves which were derived from the USBR's "Series 150 Estimating Instructions". The capital cost of the substation, penstocks, transmission lines, gates, valves, and trashracks are also included in these data.

Dependable capacities were estimated by the formula: KW = .072 QH where Q would be the flow with a plant capacity factor of 30 percent, and H is the minimum head.

CHART H: Towerhouse Power Facilities, Annual Cost and Power Revenue Data

Annual cost is based on 4 percent interest with a 50-year repayment period.

Operation, maintenance, and general expense of the powerplant are based on the installed capacity and were obtained from a curve dated March 10, 1961, which was derived from costs obtained from F.P.C. Technical Memorandum No. 1.

Included with the annual cost of the powerplant are the annual costs of a substation, penstocks, transmission lines, gates, valves, and trashracks.

Power revenues were based on $22 per kilowatt of dependable capacity and 3 mills for each kilowatt hour of average annual energy generation.

CHART I: Conveyance Facilities, Helena Reservoir to Whiskeytown Reservoir, Capital Cost-Unit Cost or Unit Revenue-Capacity Data

Chart I presents summations of the capital costs obtained from Charts B, E, and G: and summations of the annual costs obtained from Charts B, E, and H, minus the power revenue from Chart H divided by the respective export yield, giving a unit cost or unit revenue as the case may be for the conveyance system for each acre-foot of water delivered annually into Whiskeytown Reservoir.

CHART J: Remaining Clear Creek Power Facilities, Whiskeytown, Kanaka, Saeltzer, and Girvan, Capital Cost and Dependable Capacity Data

Whiskeytown Reservoir is an existing feature of the USBR's Central Valley Project, no charge was included for that reservoir; Kanaka Dam and Reservoir was estimated by the Design Unit for a normal pool elevation of 950 feet with a resultant capital cost of $4,336,000; Saeltzer Dam and Reservoir was estimated by the Design Unit for a normal pool elevation of 700 feet, with a resultant capital cost of approximately $11,700,000; cost of Girvan Dam and Reservoir was estimated by the Design Unit for a normal pool elevation of 500 feet, with a resultant capital cost of approximately $6,500,000; Girvan Tailrace Channel was estimated by the personnel of the Trinity River Division from cost of Saeltzer Tailrace Channel received from the Design Unit.

In the studies of Whiskeytown, Kanaka, Saeltzer, and Girvan Powerplants, the following criteria were used. It was considered that no irrigation water would be developed in Whiskeytown Reservoir and that the minimum pool elevation used for power generation would be 1,197 feet. Kanaka Reservoir's normal pool elevation would be set at the streambed elevation of Whiskeytown Dam (950 feet) for all export yields, in order to develop the maximum powerhead available at Kanaka Powerplant. It was considered that Saeltzer Reservoir's normal pool elevation would be set at the streambed elevation of Kanaka Dam (700 feet), and that the tailrace of Saeltzer Powerplant would be excavated to an elevation of 500 feet from streambed elevation of 553 feet. It was considered that the normal pool elevation of Girvan Reservoir would be 500 feet, and the Girvan Powerhouse tailrace channel would be excavated to an elevation of 385 feet, producing a maximum head of (500-385) 115 feet. The normal pool elevation of Iron Canyon Reservoir would be 400 feet and the minimum head on Girvan Powerplant would be (500-400) 100 feet. Kanaka and Saeltzer Powerplants would operate under constant head while Whiskeytown and Girvan Powerplants would have a slight head variation.

An analysis of the Clear Creek Export System below Towerhouse Powerplant and including Whiskeytown Powerplant; Kanaka Dam and Powerplant; Saeltzer Dam and Powerplant; and Girvan Dam, Powerplant, and Tailrace Channel, indicated that at an export yield of 500,000 acre-feet per year, it would be economical to build Whiskeytown Powerplant; Kanaka Dam and Powerplant, and Girvan Reservoir to act as an afterbay for re-regulation of the power flows. The analysis at an export yield of 1,000,000 acre-feet per year and any greater yield indicated that it would be economical to build Whiskeytown Powerplant; Kanaka Dam and Powerplant; Saeltzer Dam and Powerplant; and Girvan Dam, Powerplant, and Tailrace Channel. These studies also showed that it would be economical to construct Saeltzer Dam and Powerplant when the export yield would be 617,000 acre-feet per year or greater, and that Girvan Powerplant and Tailrace Channel should be constructed when the export yield would exceed 734,000 acre-feet per year.

Dependable capacities at Whiskeytown, Kanaka, Saeltzer, and Girvan Powerplants were estimated by the formula: $KW = .072\ QH$, where Q is the peak Q with 0.3 load factor, and H is the minimum head.

<u>CHART K</u>: Remaining Clear Creek Power Facilities, Whiskeytown, Kanaka Saeltzer, and Girvan, Annual Cost and Power Revenue Data

Annual cost is based on 4 percent interest with a 50-year repayment period.

Operation, maintenance, and general expense of the powerplants are based on the installed capacity and were obtained from the curve dated March 10, 1961, "Power Plants Annual Operation, Maintenance, and General Expense Costs".

In addition to annual costs of powerplants, the annual costs of substations, penstocks, transmission lines, gates, valves, and trashracks are included in these data.

Power revenue is based on $22 per kilowatt of dependable capacity, and 3 mills for each kilowatt hour of energy generation.

CHART L: Clear Creek Export Route, Helena Reservoir to Iron Canyon Reservoir, Summary of Capital Cost and Dependable Capacity Data

Chart L is merely a summation of Charts I and J for capital cost data, and a summation of Charts G and J for dependable capacity data.

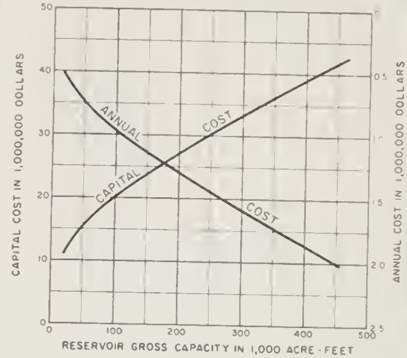
CHART M: Clear Creek Export Route, Helena Reservoir to Iron Canyon Reservoir, Summary of Annual Cost and Power Revenue Data

Chart M is a summation of annual cost data found on Charts B, E, H, and K; and a summation of power revenue data found on Charts H and K.

CHART N: Clear Creek Export Route, Helena Reservoir to Iron Canyon Reservoir, Annual Unit Cost or Revenue of Export System

Chart N is a numerical summation of the annual costs of the facilities comprising the export system from Helena Reservoir to Iron Canyon Reservoir and the power revenue from the powerplants in the system divided by the respective export yield giving a unit cost or unit revenue as the case may be.

CHART E
COST-CAPACITY DATA
TOWERHOUSE RESERVOIR



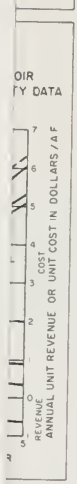
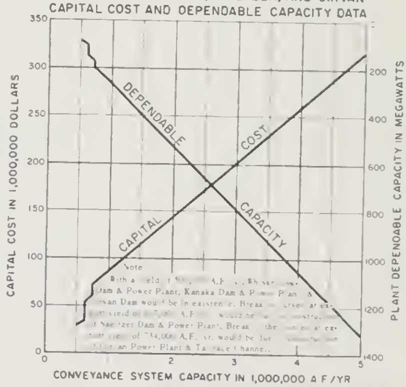


CHART J
REMAINING CLEAR CREEK POWER FACILITIES
WHISKEYTOWN, KANAKA, SAELTZER, AND GIRVAN
CAPITAL COST AND DEPENDABLE CAPACITY DATA



Note: All estimates [illegible] engineering and project administration. Estimates of equivalent annual [illegible] expenses for O.M. and R. and a capital [illegible] period [illegible] years at [illegible].

The annual value [illegible] hydroelectric power [illegible]
1. Dependable capacity per kilowatt year [illegible] $[illegible]
2. Usable energy per kilowatt hour [illegible]

Assumed monthly minimum support energy requirements [illegible] dependable power are:

ADVERSE PERIOD [illegible] NORMAL PERIOD [illegible]

[illegible]

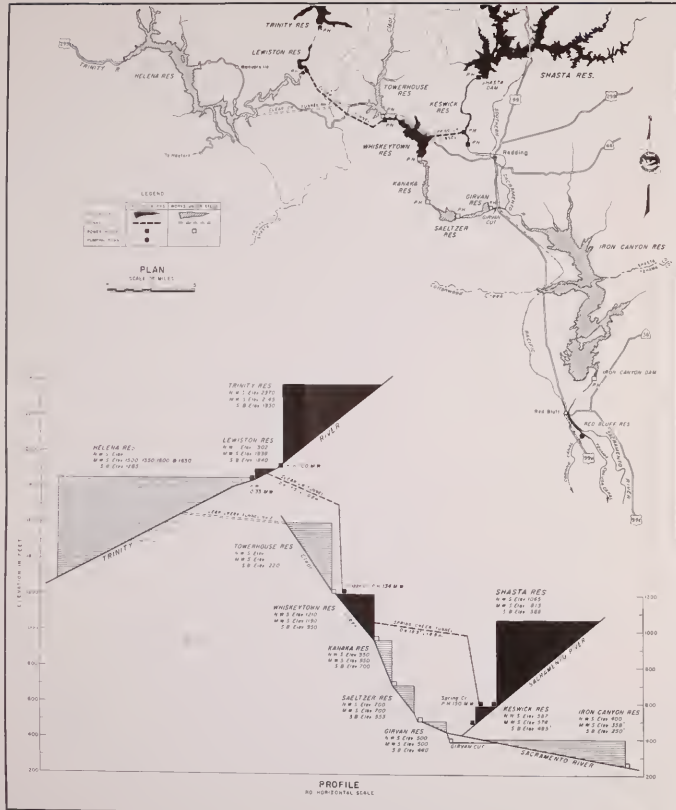
Total annual minimum support energy requirement [illegible] for a normal period.

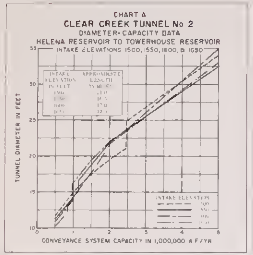
Data summarized [illegible] which would be provided by an [illegible] Res[illegible]

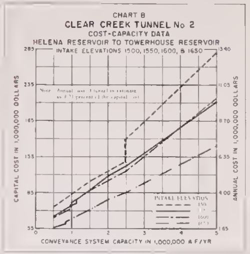
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
TRINITY RIVER DIVISION
1963

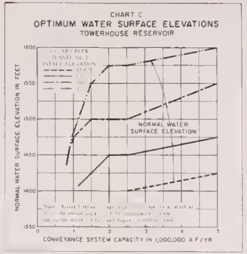
CLEAR CREEK
EXPORT CONVEYANCE FACILITIES
RECONNAISSANCE SUMMARY OF COSTS FOR THE TRANSPORT AND POWER RECOVERY FACILITIES ONLY

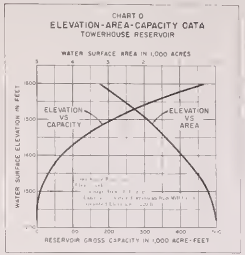
TRANSBASIN DIVERSION FROM THE TRINITY RIVER TO THE SACRAMENTO RIVER BASIN VIA THE CLEAR CREEK ROUTE WITH TUNNEL INTAKE ON THE TRINITY RIVER AT ELEVATIONS 1500, 1550, 1600 AND 1650 FEET

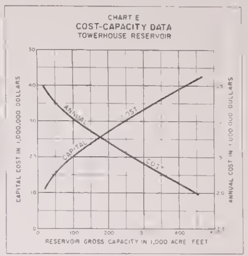


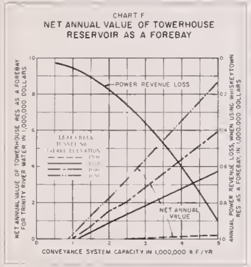


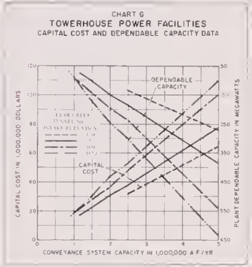


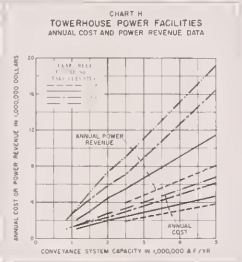


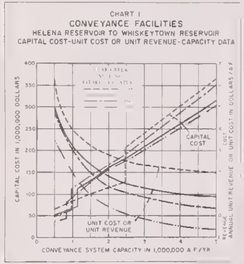


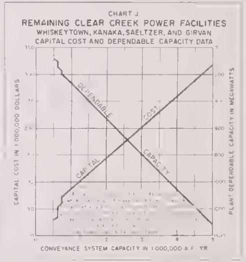


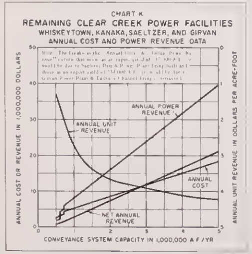


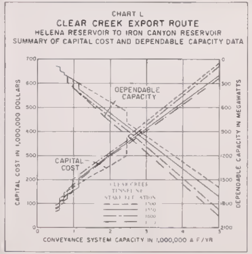


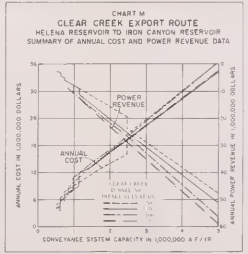


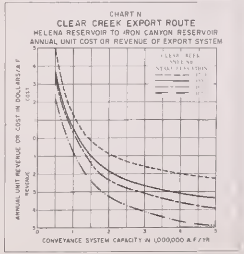












STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
TRINITY RIVER DIVISION
1963

CLEAR CREEK
EXPORT CONVEYANCE FACILITIES

RECONNAISSANCE SUMMARY OF COSTS FOR THE TRANSPORT AND POWER RECOVERY FACILITIES ONLY

TRANSBASIN DIVERSION FROM THE TRINITY RIVER TO THE SACRAMENTO RIVER BASIN VIA THE CLEAR CREEK ROUTE WITH TUNNEL INTAKE ON THE TRINITY RIVER AT ELEVATIONS 1500, 1550, 1600 AND 1650 FEET

PLATE 8A

COTTONWOOD CREEK EXPORT CONVEYANCES FACILITIES

Diversion from the Trinity River

Plate 8A presents data pertaining to the physical dimensions and the approximate cost of the conveyance facilities used to export water from the Trinity River Basin, with the Cottonwood Creek Tunnel intake elevation at 1,500 feet, via Cottonwood Creek to Fiddlers Reservoir with a N.W.S. elevation of 1,000 feet.

Studies were made for export yields of 500,000 acre-feet, 1,000,000 acre-feet, 1,500,000 acre-feet, 2,000,000 acre-feet, 2,500,000 acre-feet, and 5,000,000 acre-feet.

Two methods were given consideration for export of Trinity River water with the export tunnel intake elevation at 1,500 feet to Cottonwood Creek: (1) the smallest tunnel possible would be used to divert the flow but develop no power, and (2) a larger tunnel and a forebay reservoir would be used to reregulate a uniform inflow for peak power generation. The first method would require a tunnel of smaller diameter but of greater length due to a lower outlet elevation. Both methods were studied for various yields and tunnel outlet elevations.

Description of Data

CHART A: Cottonwood Creek Tunnel - Diameter, Capacity and Cost Data

Cottonwood Creek Tunnel would convey a uniform flow when exporting yields less than approximately 2.5 million acre-feet. For greater yields the tunnel would be oversized in the same manner that the Helena-Towerhouse Tunnel was sized in previous studies. That is, the tunnel would be sized to deliver, at a uniform rate, the amount of water required for on-peak power generation at Selvester Powerhouse during the month of August. This flow for the month of August would be 12.928 percent of the yearly flow. The tunnel capacity would be approximately 1.5 times that required for uniform flow throughout the year. Selvester Reservoir would have sufficient storage to reregulate a uniform inflow to a peaking power schedule when the annual yield from the Trinity River Development is less than 2.5 million acre-feet.

The sharp break in the tunnel diameter curve at an export yield of 700,000 acre-feet per year is that point where it would be more economical to build the Cottonwood Creek Tunnel, Selvester Reservoir and Selvester Powerplant rather than just Cottonwood Creek Tunnel with no power facilities. The increase in diameter is due to the decrease in head available for tunnel flow.

Costs of Cottonwood Creek Tunnel with intake elevation of 1,500 feet were taken from cost curve furnished by the Design Unit to preliminary standards entitled "Cottonwood Creek Tunnel Capital Cost Curve" April 1962. This curve was extended for tunnel diameters greater than 25 feet.

The sharp break occurs in the capital cost curve at an export yield of 700,000 acre-feet per year. Beyond this point it would be more economical to construct Cottonwood Creek Tunnel, Selvester Reservoir, and Selvester Powerplant rather than just Cottonwood Creek Tunnel and no power facilities. The construction of Selvester Dam would decrease the head available to tunnel flow thereby increasing the required diameter and increasing the cost of the tunnel.

Annual cost of the tunnel was estimated as 4.705 percent of the capital cost of the tunnel.

CHART B: Selvester Reservoir - Optimum Water Surface Elevations

Optimum water surface elevations of Selvester Reservoir are shown for export yields of 500,000; 1,000,000; 1,500,000; 2,000,000; 2,500,000; and 5,000,000 acre-feet per year. This curve shows that Selvester Reservoir would not be used until an export yield of approximately 700,000 acre-feet per year is reached. The reservoir for yields of 700,000; 1,000,000; 1,500,000; 2,000,000; and 2,500,000 would operate on a Q H basis; for a yield of 5,000,000 acre-feet per year Selvester Reservoir would act as a forebay reservoir and regulates the uniform power flow to a peaking power flow which would require approximately 50,000 acre-feet of active storage.

The water surface elevations of Selvester Reservoir were studied only at even 25-foot intervals. The optimum water surface elevations were plotted for yields of 700,000; 1,000,000; 1,500,000; 2,000,000; 2,500,000; and 5,000,000 acre-feet per year and straight lines drawn between the plotted points.

CHART C: Selvester Reservoir - Elevation, Area, Capacity Data

The reservoir area was planimetered from the USGS quadrangles of Chanchelulla Peak scale 1:62,500; contour interval of 100 feet, and Ono scale 1:62,500; contour interval of 50 feet. The reservoir capacity was computed by the average end area method.

CHART D: Selvester Reservoir - Cost, Capacity Data

The capital cost of Selvester Dam and Reservoir was estimated, by the Northern Branch Design Unit, to preliminary standards for three sizes: normal water surface elevation 1,300 feet, and gross storage capacity of 137,000 acre feet; normal water surface elevation 1,400 feet, and gross storage capacity of 351,000 acre-feet; and normal water surface elevation 1,500 feet, and gross storage capacity of 630,000 acre-feet. A curve of these three points was then drawn in January 1961 and entitled "Selvester Cost Curve".

The annual cost is based on a four percent interest rate with a 50-year repayment period. Operation, maintenance, and general expense of the reservoir is based on the gross storage capacity as set up in the planning memorandum of March 16, 1961, "Schedule of Annual Costs".

CHART E: Selvester Power Facilities - Capital Cost and Dependable Capacity Data

Selvester Powerplant was economically sized for yields of 500,000; 1,000,000; 1,500,000; 2,000,000; 2,500,000; and 5,000,000 acre-feet per year with tunnel intake elevation on the Trinity River of 1,500 feet. This size takes into consideration Cottonwood Creek Tunnel, Selvester Dam and Reservoir, and Selvester Powerplant. Normal pool elevations at Selvester Reservoir were studied at even 25-foot intervals.

Selvester Powerplant would not be built until the export yield was 700,000 acre-feet per year or greater. For yields of 700,000, 1,000,000; 1,500,000; 2,000,000; and 2,500,000 acre-feet per year Selvester Powerplant would operate on a "Constant Q H" basis; that is, as the reservoir level rises, the release would decrease and vice versa so that the product of the flow and the head are always constant. For a yield of 5,000,000 acre-feet per year, the reservoir would not be large enough to operate on the one-year carry-over basis as would be the case with export yields up to 2,500,000 acre-feet per year with the larger yields the reservoir would operate in a manner similar to the proposed Towerhouse Reservoir; that is, by operating on a weekly basis it would provide sufficient storage to reregulate the inflow on a uniform power schedule and make releases on a peaking power schedule for 5,000,000 acre-feet per year. This amounts to 50,000 acre-feet of storage. With an export yield of 5,000,000 acre-feet per year, Cottonwood Creek Tunnel would be sized to carry the power flow required for the month of August; this means that Cottonwood Creek Tunnel would be sized to carry about 50 percent more water than if it were sized for uniform flow.

The power plant costs for each of the yields were estimated from curves dated February 28, 1961, which were derived from the USBR's "Series 150 Estimating Instructions". In addition to the capital cost of the powerplant, the capital costs of substations, penstocks, transmission lines, gates, valves, and trashracks are included.

Dependable capacities were estimated for yields of 500,000; 1,000,000; 1,500,000; 2,000,000; and 2,500,000 acre-feet per year, assuming a constant Q H, where kw = .072 Q H and Q is in cfs with load factors of .3 and H is in feet. For a yield of 5,000,000 acre-feet per year the dependable capacities were estimated by the formula kw = .072 Q H where Q is the peak Q with a .3 load factor, and H is the minimum head.

CHART F: Selvester Power Facilities - Annual Cost and Power Revenue Data

Annual cost is based on four percent interest with a 50-year repayment period.

Operation, maintenance, and general expense of the powerplant are based on the installed capacity and were obtained from the curve dated March 10, 1961, "Powerplants Annual Operation, Maintenance, and General Expense Costs".

The annual cost of powerplant includes the annual costs of substations, penstocks, transmission lines, gates, valves, and trashracks.

Annual power revenue is based on a unit value of $22 per kilowatt of dependable capacity, and three mills for each kilowatt hour of average annual energy generation.

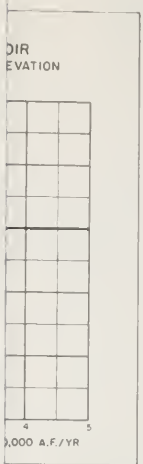
Net annual power revenue is the difference between the annual power revenue, and the annual cost of the powerplant.

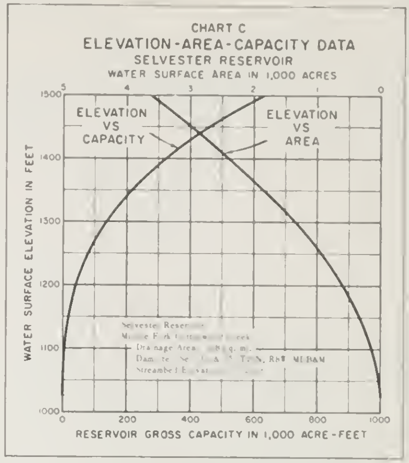
CHART G: Cottonwood Creek Export Route - Capital Cost, Annual Cost, Power Revenue, Capacity Data

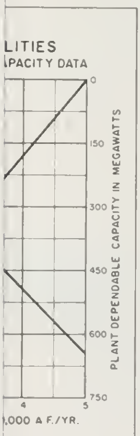
Chart G is a summation of the capital costs from Chart A, D, and E; a summation of annual costs from Chart A, D, and F; annual power revenue from Chart F; and a numerical summation of power revenue and annual cost to give a net annual cost or net annual revenue curve.

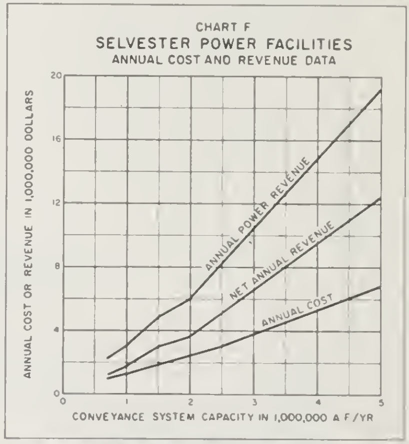
CHART H: Cottonwood Creek Export Route, Helena Reservoir to Fiddlers R servoir, Annual Unit Cost or Revenue

Chart H is a numerical summation of the annual cost of the facilities comprising the export conveyance system from Helena Reservoir on the Trinity River to Fiddlers Reservoir on Cottonwood Creek and the power revenue from the powerplant in the system divided by the respective export yield giving a unit cost or unit revenue as the case may be.









Note: [illegible] engineering and project administration. [illegible] expenses for O.M. and R. and a capital recovery period [illegible] years at [illegible]

The annual value of hydroelectric power [illegible]
1. Dependable capacity per kilowatt year [illegible]
2. Useable energy per kilowatt hour [illegible]

Assumed monthly minimum support energy requirements [illegible] are

ADVERSE PERIOD [illegible] NORMAL PERIOD [illegible]

Total annual minimum support energy [illegible] 1800 kwh [illegible] for a normal period.

Data summarized on this plate does [illegible] Reservoir [illegible] Conveyance System

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION

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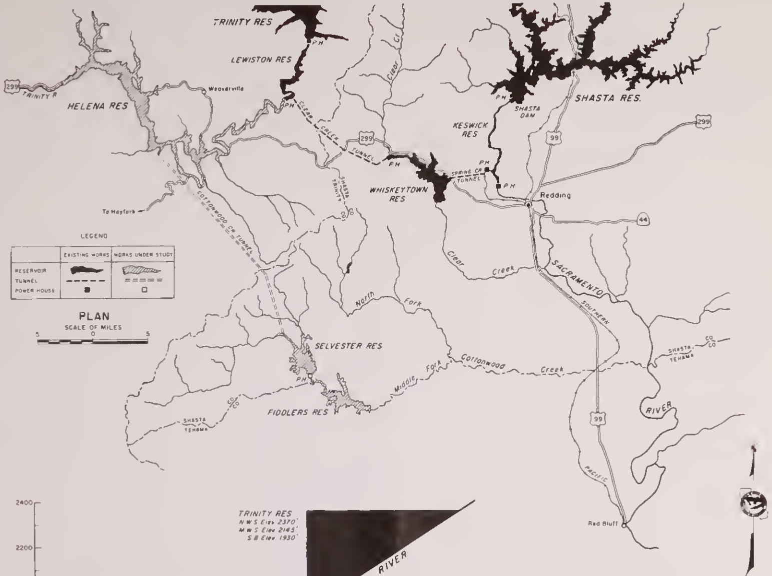
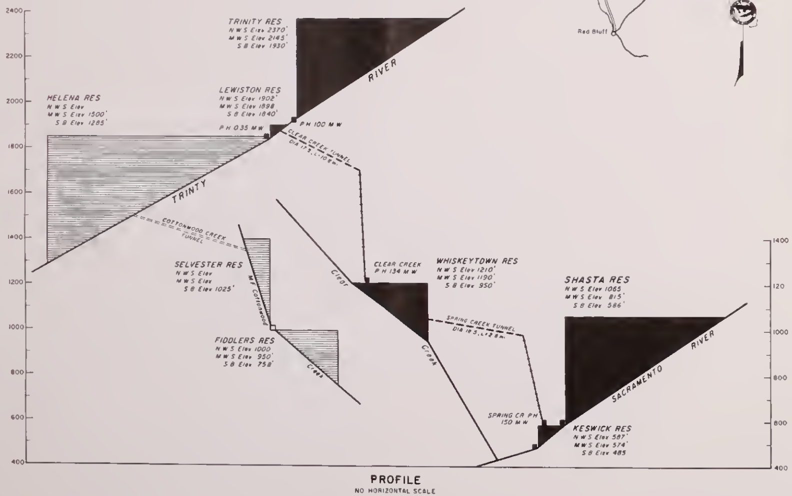
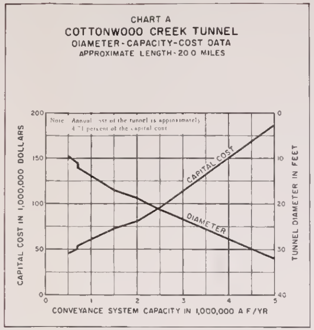
COTTONWOOD CREEK EXPORT CONVEYANCE FACILITIES

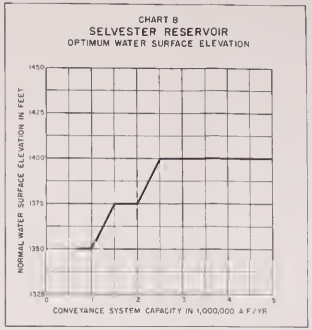
RECONNAISSANCE SUMMARY OF COSTS FOR THE TRANSPORT AND POWER RECOVERY FACILITIES ONLY

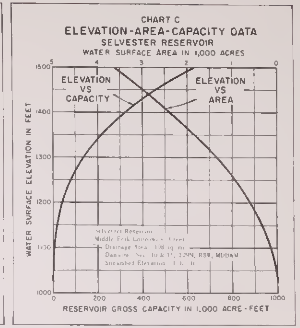
TRANSBASIN DIVERSION FROM THE TRINITY RIVER TO THE SACRAMENTO RIVER BASIN VIA THE COTTONWOOD CREEK ROUTE WITH TUNNEL INTAKE ON THE TRINITY RIVER AT ELEVATION 1500 FEET

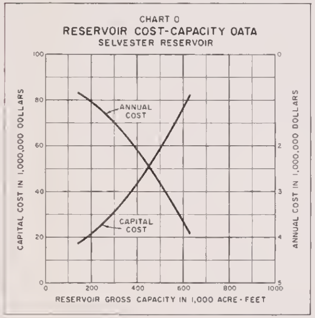


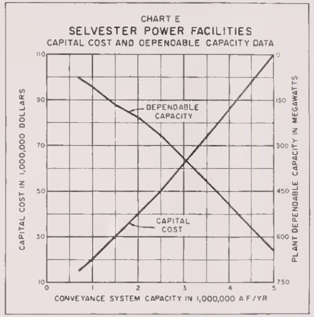


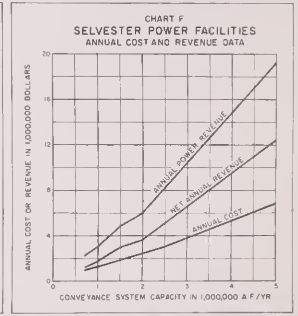


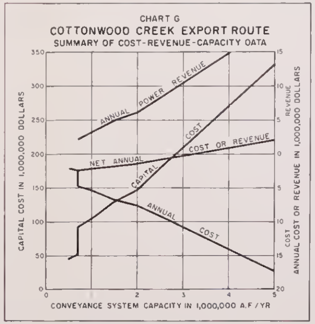


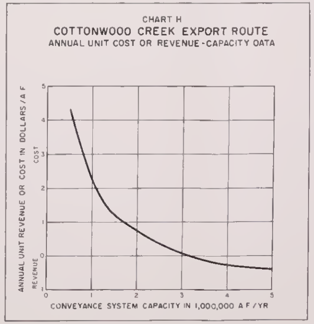












Note: All estimates of capital costs include allowances of [illegible] for contingencies and [illegible] engineering and project administration. Estimates of equivalent annual cost include annual expenses for O.M. and R. and a capital recovery period of [illegible] years at 4.0% interest.

The annual value of hydroelectric power is considered to consist of two components:
Dependable capacity per kilowatt year — [illegible]
Usable energy per kilowatt hour — [illegible]

Assumed monthly minimum support energy requirements to sustain dependable power are:

ADVERSE PERIOD		NORMAL PERIOD	
Oct 100 kwh kw	Apr 190 kwh kw	Oct 140 kwh kw	Apr 140 kwh kw
Nov 170 "	May 200 "	Nov 110 "	May [illegible]
Dec 180 "	June 2[illegible] "	Dec [illegible] "	June 180 "
Jan 160 "	July 3[illegible]0 "	Jan [illegible] "	July [illegible]40 "
Feb 140 "	Aug 340 "	Feb [illegible] "	Aug. 21[illegible] "
Mar 220 "	Sept 240 "	Mar [illegible]	Sept 180 "

Total annual minimum support energy requirement is 2[illegible]30 kwh kw for an adverse period and 1800 kwh kw for a normal period.

Data summarized on this plate does not include the reregulatory and additional power development functions which could be provided by the [illegible] Reservoir Complex to the West Side Conveyance System.

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COTTONWOOD CREEK EXPORT CONVEYANCE FACILITIES

RECONNAISSANCE SUMMARY OF COSTS FOR THE TRANSPORT AND POWER RECOVERY FACILITIES ONLY

TRANSBASIN DIVERSION FROM THE TRINITY RIVER TO THE SACRAMENTO RIVER BASIN VIA THE COTTONWOOD CREEK ROUTE WITH TUNNEL INTAKE ON THE TRINITY RIVER AT ELEVATION 1500 FEET

PLATE 9
INITIAL TRINITY RIVER CONSERVATION FEATURE
Helena Reservoir

Plate 9 presents the physical data and the approximate cost of the first stage of water development in the Trinity River Basin. Studies were made for power schedule and uniform schedule releases from Helena Reservoir with minimum pool elevations of 1,500, 1,550, 1,600, and 1,650 feet.

Description of Individual Charts

CHART A: Helena Reservoir - Elevation, Area, and Capacity Data

This chart is self-explanatory and requires no further discussion.

CHART B: Helena Reservoir - Yield and Capacity Data

Chart B gives the annual yield of Helena Reservoir for various active storages. Critical periods are shown on the curves.

CHART C: Helena Reservoir - Cost and Capacity Data

This chart is self-explanatory and requires no further discussion.

CHART D: Helena Reservoir - Yield vs. Normal Water Surface Elevation

Chart D is a combination of information found on Charts A and B into a more usable form. Chart D provides the annual export yield available from Helena Reservoir for any given normal pool elevation. This yield may be on a power schedule or uniform schedule, and minimum pool elevations of Helena Reservoir were 1,500, 1,550, 1,600, or 1,650 feet.

CHART E: Helena Reservoir - Capital Cost, Annual Cost, and Yield Data

Chart E is a combination of information found on Charts A, C, and D into a more usable form. Chart E provides the capital and annual costs of Helena Reservoir for various annual yields. This yield is on a power schedule, and minimum pool elevations of Helena Reservoir were 1,500, 1,550, 1,600, and 1,650 feet.

CHART F: Helena Reservoir - Capital Cost, Annual Cost, and Yield Data

Chart F is the same as Chart E only the yield from Helena Reservoir is on a uniform schedule.

CHART G: Helena Reservoir - Unit Cost vs. Yield

Chart G is merely the annual costs found on Chart E divided by the respective reservoir annual yields which gives the annual unit cost and is plotted against the respective reservoir annual yields. Helena Reservoir yield is on a power schedule and minimum pool elevations were 1,500, 1,550, 1,600, and 1,650 feet.

CHART H: Helena Reservoir - Unit Cost vs. Yield

Chart H is the same as Chart G, only the yield of Helena Reservoir is on a uniform schedule, and data is obtained from Chart F.

CHART I: Helena Reservoir - Storage Requirement and Yield Depletion vs. Annual Quantity of Pumped Water

Chart I gives the storage requirement and yield depletion in Helena Reservoir for future water from the Trinity and Klamath Rivers that will be pumped into Helena Reservoir on an "off-peak" schedule and released on an "on-peak" schedule for power generation.

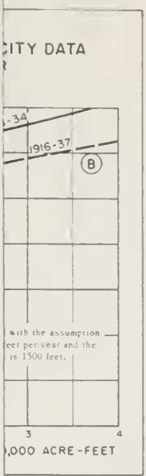
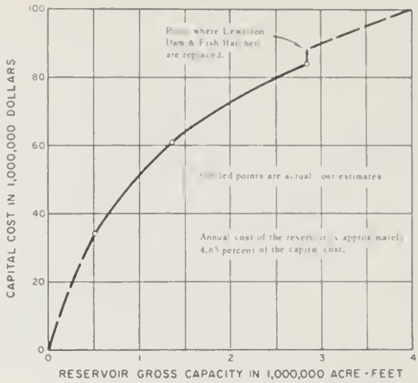


CHART C
RESERVOIR COST-CAPACITY DATA
HELENA RESERVOIR



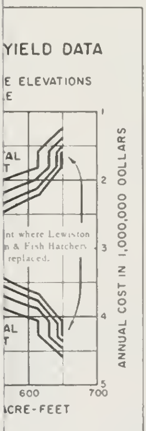
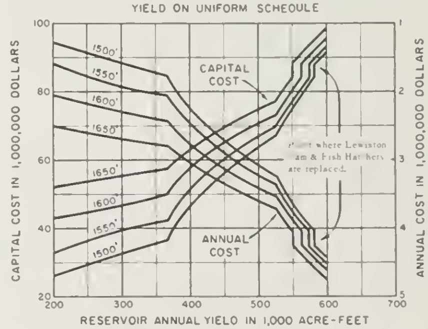
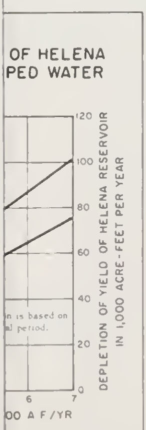


CHART F
CAPITAL COST-ANNUAL COST-YIELD DATA
HELENA RESERVOIR
USING VARIOUS MINIMUM WATER SURFACE ELEVATIONS
YIELD ON UNIFORM SCHEDULE





*Yield on the power schedule is distributed on a [illegible] power load schedule. That is, re[illegible]leases vary monthly in accordance with the Northern California power demand distribution. During years of normal runoff it is assumed that the reservoir releases for dependable power generation purposes may be reduced by approximately [illegible] due to the availability of support energy being generated as non-dependable during normal or wet years.

All estimates of capital costs include allowances of 15% for contingencies, [illegible] for engineering and project administration. Estimates of annual cost include annual expenses for operation, maintenance and replacement. Capital recovery period is [illegible] years at [illegible] interest.

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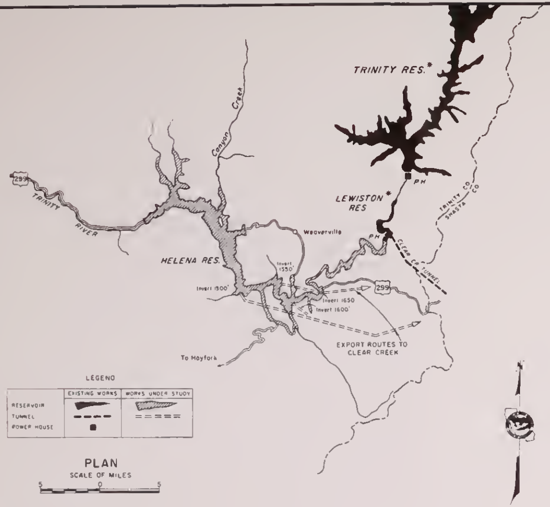
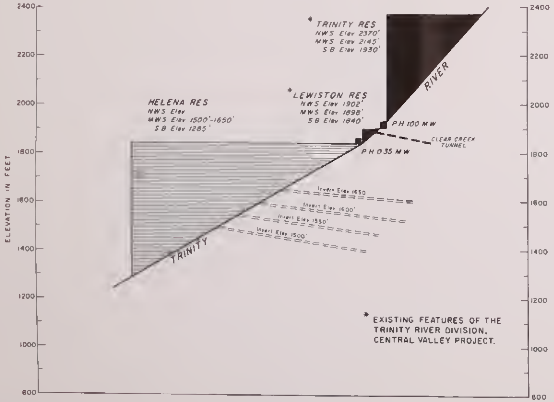
INITIAL TRINITY RIVER CONSERVATION FEATURE
RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES
AS AN INCREMENT ABOVE THE EXISTING TRINITY RIVER DIVISION, OF THE CENTRAL VALLEY PROJECT



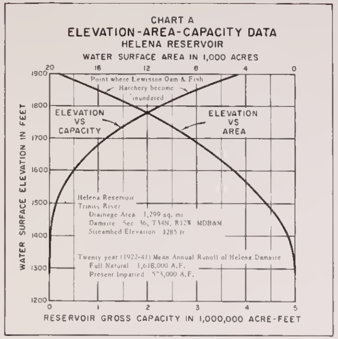
PLAN

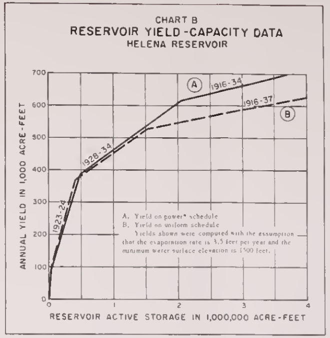
SCALE OF MILES

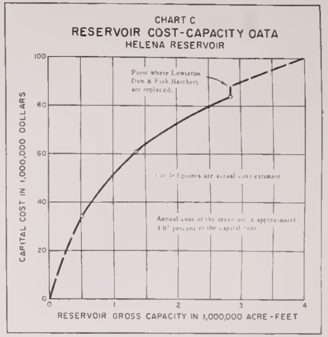


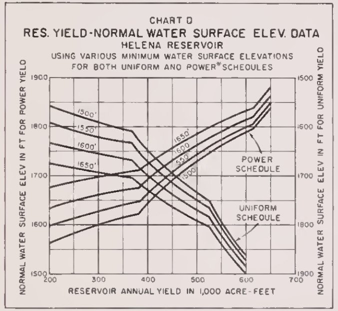
PROFILE

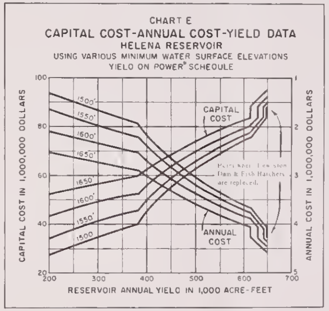
NO HORIZONTAL SCALE

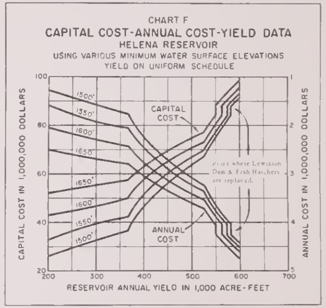


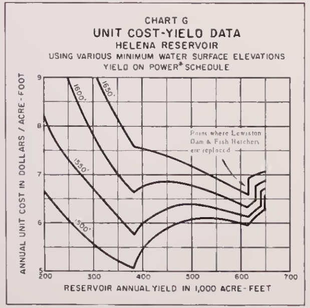


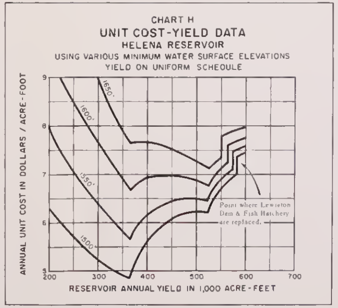


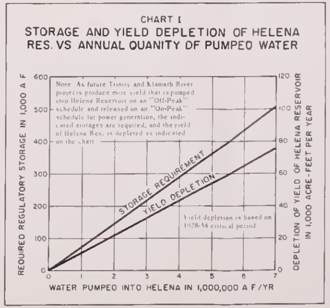












*Yield on the power schedule is distributed on a typical power load schedule. That is, releases vary monthly in accordance with the Northern California power demand distribution. During years of normal runoff it is assumed that the reservoir releases for dependable power generation purposes may be reduced by approximately 32% due to the availability of surplus energy being generated as non-dependable during normal or wet years.

All estimates of capital costs include allowances of 15% for contingencies, 15% for engineering and project administration. Estimates of annual cost include annual expenses for operation, maintenance and replacement. Capital recovery period is 50 years at 4.0% interest.

STATE OF CALIFORNIA
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NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
TRINITY RIVER DIVISION
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INITIAL TRINITY RIVER CONSERVATION FEATURE

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES
AS AN INCREMENT ABOVE THE EXISTING TRINITY RIVER DIVISION, OF THE CENTRAL VALLEY PROJECT

PLATE 10A
SOUTH FORK TRINITY GRAVITY PROJECT

Plate 10A presents the physical data and the approximate cost of the South Fork of the Trinity River development by gravity diversion. This development could follow the construction of Helena Reservoir, or it might be built in conjunction with Helena Reservoir, and would include Eltapom Dam and Reservoir, and the Eltapom-Helena Tunnel.

Studies were made for power schedule and uniform schedule releases from Eltapom Reservoir with minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1,650 feet.

Costs shown on this plate were estimated before our latest preliminary geologic investigation of the Eltapom damsite which showed at least two major fault zones that cross the dam axis under the maximum fill section and constitute a major foundation defect. These costs should be used with extreme care until further geologic exploration is accomplished and new cost estimates made available.

Description of Individual Charts

CHART A: Eltapom Reservoir - Elevation, Area, and Capacity Data

Data for this chart were derived from USGS manuscripts with a scale of 1-inch = 400 feet, up to elevation 1,800, then from USGS quadrangles with a scale of 1:62,500. Capacity was computed by the average-end area method.

CHART B: Eltapom Reservoir - Yield and Capacity Data

Chart B presents the annual yield of Eltapom Reservoir for power and uniform schedule releases for various active storages. Critical periods for reservoir operation are shown on the curves. Yields indicated are in excess of evaporation and fish releases. See the description of Plate 10B, Chart D for more information.

CHART C: Eltapom Reservoir - Cost and Capacity Data

Chart C gives the capital cost of Eltapom Dam and Reservoir for various gross storages. This curve was made from cost estimates which were made by the Northern Branch Design Unit.

This cost curve should be used with some reservation. Since this plate was printed, additional geologic investigation at the Eltapom damsite have revealed at least two major fault zones which cross the dam axis under the maximum fill section and constitute a major foundation defect. Cost estimates of Eltapom Dam have not been reviewed by the Staff Engineering Section of the Division of Design and Construction, and may be altered a great deal from our original costs. Until further geologic exploration is accomplished at the Eltapom damsite, good cost estimates of the proposed Eltapom Dam cannot be made available.

CHART D: Eltapom Reservoir - Normal Water Surface Elevation vs. Yield Data

Chart D is a combination of information found on Charts A and B into a more usable form. Chart D provides the annual export yield available from Eltapom Reservoir for any given normal pool elevation. This yield can be on a power or uniform schedule, and curves are drawn for minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1,650 feet.

CHART E: Eltapom Reservoir - Capital Cost and Yield Data

Chart E is a combination of information found on Charts A, C, and D into a more usable form. Chart E provides the capital costs of Eltapom Reservoir for various annual export yields. This yield is on a power and a uniform schedule and curves are drawn for minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1,650 feet.

These curves should be used with extreme care, and are subject to great revision.

CHART F: Eltapom-Helena Tunnel - Cost and Diameter Data

Chart F is a plot of the capital cost of the Eltapom-Helena Tunnel vs. the diameter of the tunnel. This curve was drawn from cost estimates made for 10, 15, 20, and 25-foot tunnels, by the Northern Branch Design Unit.

CHART G: Eltapom-Helena Tunnel, Diameter and Yield Data

This chart shows the optimum tunnel diameters for any yield between 300,000 and 700,000 acre-feet, for four minimum pool condition of Helena, 1,500, 1,550, 1,600, and 1,650 feet. To determine the proper tunnel slope it was necessary to consider the cost of both the tunnel and Eltapom Reservoir. In this evaluation it was found that the tunnel slope should be flatter as the yield increases. This is because the reservoir cost becomes increasingly more expensive with each additional foot of height, while the tunnel becomes more expensive for a larger bore but at a decreasing rate.

Although tunnel diameters are plotted for both uniform and power schedule yields, it is not likely that the tunnel would have to be oversized to accommodate water on the power schedule since Helena Reservoir could probably provide the reregulatory storage required to change a uniform yield to a power yield.

CHART H: Eltapom-Helena Tunnel - Diameter and Yield Data

Chart H is a plot of the increase in the Eltapom-Helena Tunnel diameter due to annual export yield from the Mad and Van Duzen Rivers. The curves are plotted for a uniform and a power schedule release from the Mad and Van Duzen Rivers System, and are for minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1650. These curves were plotted with the assumption that Eltapom Reservoir would have a normal pool elevation of 1,840 feet.

The Eltapom-Helena Tunnel was sized for a uniform annual flow.

CHART I: Eltapom-Helena Tunnel - Capital Cost and Yield Data

Chart I is the combination of data presented in Charts F and G. Chart I is a plot of capital cost of Eltapom-Helena Tunnel vs. the annual export yield. This export yield is on a uniform or power schedule and curves are drawn for minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1,650 feet.

CHART J: Eltapom-Helena Tunnel - Capital Cost and Yield Data

Chart J is a plot of the increase in the Eltapom-Helena Tunnel capital cost due to annual export yield from the Mad and Van Duzen Rivers. The curves are plotted for a uniform and a power schedule release from the Mad and Van Duzen Rivers system, and are for minimum pool elevations in Helena Reservoir of 1,500, 1,550, 1,600, and 1,650 feet. These curves were plotted with the assumption that Eltapom Reservoir would have a normal pool elevation of 1,840 feet.

Chart J also presents the approximate increase in unit cost to size the Eltapom-Helena Tunnel to carry the export water from the Mad and Van Duzen Rivers System.

CHART K: South Fork Trinity River Development in Helena Reservoir - Capital Cost and Yield Data

Chart K is a combination data found on Charts E and I and gives the total capital cost for the South Fork of the Trinity River Development in Helena Reservoir.

CHART L: South Fork Trinity River Development in Helena Reservoir - Unit Cost and Yield Data

Chart L is a combination of annual cost data that can be obtained from Charts E and I, and this total annual cost is then divided by the respective annual export yield from Eltapom Reservoir to give a total annual unit cost of South Fork Trinity River water in Helena Reservoir, which is plotted against the respective annual export yield.

TUNNEL DIAMETER IN FT. FOR UNIFORM SCHEDULE

ANNUAL UNIT COST IN DOLLARS/ACRE-FOOT FOR UNIFORM SCHEDULE

CHART D

NORMAL WATER SURFACE ELEV YIELD DATA

ELTAPOM RESERVOIR

FOR BOTH UNIFORM AND POWER SCHEDULES

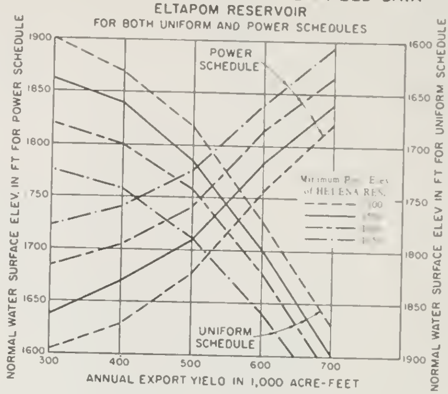


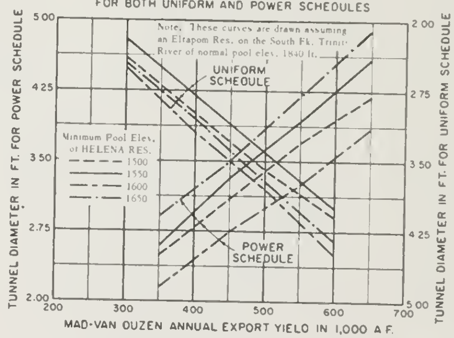
CHART H

DIAMETER-YIELD DATA

ELTAPOM-HELENA TUNNEL

INCREASE IN TUNNEL DIA DUE TO MAD-VAN DUZEN RIVERS DEVELOPMENT

FOR BOTH UNIFORM AND POWER SCHEDULES



Note: All estimates of capital costs include allowances of 15% for contingencies and 15% for engineering and project administration. Estimates of annual costs include annual expenses for operation, maintenance, and replacement. Capital recovery period is 50 years at 4.[illegible] interest.

Water developed on a power schedule has the following monthly distribution

ADVERSE PERIOD			
Oct.	7.6%	Apr.	7.2%
Nov.	6.5%	May	7.6%
Dec.	6.8%	Jan.	9.9%
Jan.	6.1%	Jul	12.6%
Feb.	5.3[illegible]	Aug.	1[illegible].9%
Mar.	8.4%	Sept.	9.[illegible]%
		Total	100.0%

NORMAL PERIOD			
Oct.	5.3%	Apr.	5.3[illegible]
Nov.	5.3%	May	7.6%
Dec.	4.2%	Jun.	6.8[illegible]
Jan.	2.[illegible]	Jul.	[illegible]
Feb.	[illegible]	Aug.	8.[illegible]
Mar.	4.[illegible]	Sept.	[illegible]8
		Total	[illegible]8.4[illegible]

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NORTH COASTAL AREA INVESTIGATION

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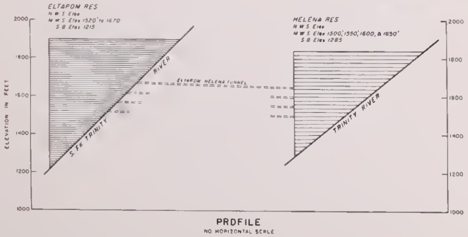
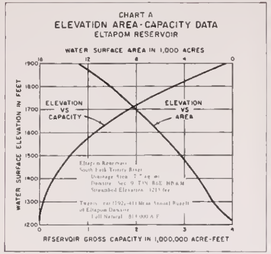
1963

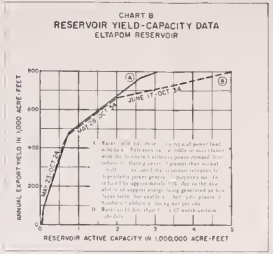
SOUTH FORK TRINITY GRAVITY PROJECT

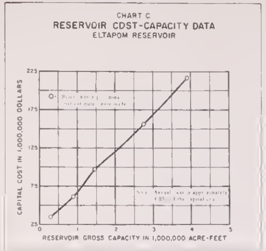
ALTERNATIVE TO S. FK. TRINITY PUMP PROJECT

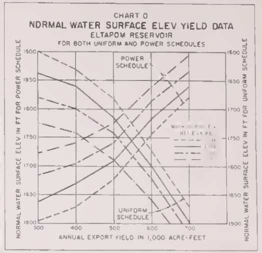
RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES AND CONVEYANCE TO HELENA RESERVOIR WITH MINIMUM WATER SURFACE ELEVATIONS OF 1500, 1550, 1600, AND 1650 FEET

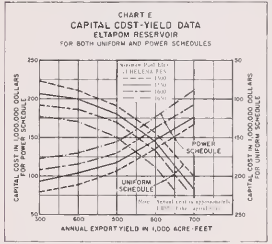


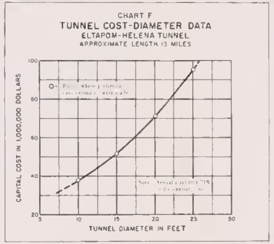


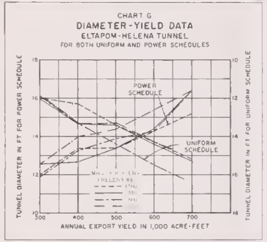


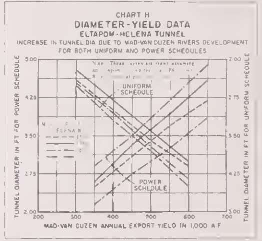


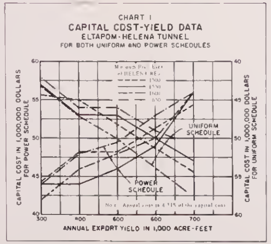


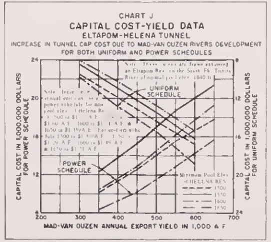


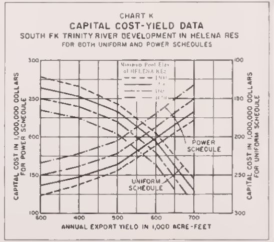


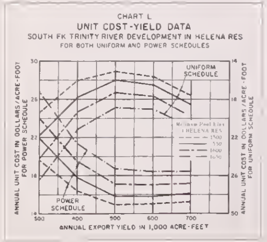












STATE OF CALIFORNIA
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TRINITY RIVER DIVISION
1963

SOUTH FORK TRINITY GRAVITY PROJECT
ALTERNATIVE TO S. FK. TRINITY PUMP PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES AND CONVEYANCE TO HELENA RESERVOIR WITH MINIMUM WATER SURFACE ELEVATIONS OF 1500, 1550, 1600, AND 1650 FEET

PLATE 10B
SOUTH FORK TRINITY PUMP PROJECT

General Information

The purpose of this plate is to present data to analyze the South Fork Trinity Pump Project and compare it with the South Fork Trinity Gravity Project, as a second increment of the Trinity River Development.

The pumping plan shown on this plate consists of Eltapom Reservoir, War Cry Tunnel, Beartooth Reservoir, New River Tunnel, Burnt Ranch Reservoir and Helena Pumping Plant.

Eltapom Reservoir would have a minimum pool elevation of about 1,330 to 1,340 feet, depending upon the desired yield. Water from Eltapom Reservoir would be carried to Burnt Ranch Reservoir via the War Cry Tunnel. This tunnel would be made large enough to carry the yield of the later staged Mad-Van Duzen Project also.

Beartooth Reservoir would have two functions; first to divert New River to Burnt Ranch, and second to provide storage for fish releases which must be made down New River. The normal pool elevation of Beartooth Reservoir would be at the same elevation as the diversion intake and would be contingent upon the normal pool of Burnt Ranch Reservoir.

The capacity of the Helena Pumping Plant would be based on heads resulting from Helena Reservoir having a normal pool elevation of 1,837 feet, a minimum pool elevation of 1,650 feet and an average water surface elevation of 1,777 feet. If the desired yield of Burnt Ranch is increased, its required normal pool elevation would also increase, thereby decreasing the pumping head. However, if and when a pumping plant is needed at Burnt Ranch Dam for future stages, a higher water surface in Burnt Ranch Reservoir will result in a higher lift at that pumping plant.

Due to the uncertain geology of Eltapom damsite a high contingency factor has been applied to it for high dams. This has made the cost of water for the Gravity Plan higher, thus making the Pump Plan appear more favorable.

Operation of Beartooth and Burnt Ranch Reservoirs

Beartooth Dam and Reservoir would serve to divert New River flow into Burnt Ranch Reservoir and to provide water for fisheries below Beartooth and Burnt Ranch Dams. Only flow in excess of 150 cfs during the spawning time and 100 cfs at other times would be diverted or stored. Diversions through the New River Tunnel could not be made unless Beartooth Reservoir is full. Fish releases made during the summer and early fall would be cold due to the depth from which the water is drawn. A yield study based upon historical runoff indicated that dead storage would have been reached in February of 1924.

Burnt Ranch Reservoir would have a base fish release of 50 cfs, but would release more much of the time, particularly in the summer. These flows would augment the natural flow below both dams and the release or spill from Beartooth Reservoir to maintain a flow on the Trinity below New River of 200 cfs during the spawning time and 150 cfs during the remaining time.

The minimum pool elevation of Burnt Ranch Reservoir would be 1,285 feet, the same as streambed elevation at Helena damsite. This would make the depth of the water at Burnt Ranch Dam no less than 415 feet. Burnt Ranch Reservoir would provide storage for the incremental flow below Helena Dam and for water diverted from New River.

Sizing Burnt Ranch Reservoir

To determine the proper size for Burnt Ranch Reservoir, it was necessary to evaluate the cost of the pumping at Helena and Burnt Ranch Dams, as well as the cost of Burnt Ranch Reservoir itself. This evaluation was made for three conditions; South Fork Trinity Project yield only, then adding the yield of the Mad-Van Duzen Project, and finally adding 6,000,000 acre-feet which would be pumped annually from the Klamath River. Under the last two conditions the proper size Burnt Ranch Reservoir would be such that it would yield 200,000 acre-feet annually, with New River. In the plate's concluding summary charts, the yields reflect 200,000 acre-feet from Burnt Ranch Reservoir and the remainder from Eltapom Reservoir.

In order to limit the number of alternatives, the minimum pool elevation of Helena Reservoir was assumed to be 1,650 feet, the normal pool elevation 1,837 feet and the average water surface elevation 1,777 feet. If and when pumping is required from the lower Trinity, it was assumed that the water level below Burnt Ranch would be constant at 870 feet (Ironside Reservoir).

Description of Individual Charts

CHARTS A, B, AND C: Area-Capacity Curves for Eltapom, Burnt Ranch and Beartooth Reservoirs

Data for Eltapom Reservoir were derived from USGS manuscripts with a scale of 1:15,840, up to elevation 1,800, then from USGS quadrangles with a scale of 1:62,500 above that.

Data for Burnt Ranch Reservoir were derived from DWR river survey maps, scale 1-inch = 400 feet, up to elevation 1,500, then from USGS quadrangles, scale 1:62,500, above 1,500.

Data for Beartooth Reservoir were derived from USGS quadrangles with a scale of 1:62,500.

CHART D: Yield-Capacity Data for Eltapom Reservoir

This curve shows the amount of active storage needed at Eltapom Reservoir to produce a desired export yield. The yield indicated is in excess of evaporation and releases for stream maintenance. The evaporation losses were based on a rate of 2.26 feet per year.

Since fish flows requirements below Eltapom Dam are quite large due to the important fishery on the South Fork of the Trinity River, some study and research were deemed necessary. The following is a summary of this:

In Bulletin No. 2, the Department of Fish and Game recommended 1,000 cfs for October through March and 100 cfs the other months. The runoff records of the Salyer gage indicate that flows of less than 100 cfs rarely occur before the middle of August, and in some years the flow is greater than 100 cfs throughout the year. Therefore, it would seem that 100 cfs is insufficient to maintain the present trout fishery.

By using a hatchery below Eltapom Dam instead of releasing the full 1,000 cfs to the spawning area near Salyer some water could be saved.

In order to determine the amounts of water which would be released to meet the desired schedule, it was assumed that the incremental runoff between Eltapom and Salyer gage is 17.5 percent of the total flow at Eltapom. However, even when there would be enough incremental water to meet the schedule at Salyer, some water would be released from storage in order to assure a desirable flow between the dam and Grouse Creek (the main tributary between Eltapom and Salyer gage), and to operate a fish hatchery below the dam.

Eltapom Creek flows into the South Fork Trinity River just below Eltapom damsite. The flow of Eltapom Creek would amount to perhaps 2.6 percent of the flow into Eltapom Reservoir. Although this creek is small, it would reduce the amount of water released from the reservoir, particularly during the winter.

Following is a chart of the flows which were considered to be required in the South Fork of the Trinity River below Eltapom Dam to satisfy fishery requirements.

Month	Required flow at Salyer Gage		Required flow below Eltapom Creek		Minimum release from Eltapom Res.	
	cfs	1,000 AF	cfs	1,000 AF	cfs	1,000 AF
Oct.	200	12	150	9	50	3
Nov.	400	24	150	9	50	3
Dec.	400	24	150	9	50	3
Jan.	300	18	150	9	50	3
Feb.	300	18	150	9	50	3
Mar.	300	18	150	9	50	3
Apr.	150	9	100	6	50	3
May	150	9	100	6	50	3
June	150	9	100	6	50	3
July	150	9	100	6	50	3
Aug.	150	9	100	6	50	3
Sept.	150	9	100	6	50	3
TOTAL		168		90		36

CHART E: Yield-Capacity Data for Burnt Ranch Reservoir

In this chart, the yield-capacity relationship of Burnt Ranch Reservoir is shown, with and without water diverted from New River.

Water from New River would be diverted at Beartooth Dam by a direct diversion through an 8-mile tunnel. Storage at Beartooth would be used only for fish releases.

An economic study was made to select the proper sizes of Beartooth Dam and New River Tunnel for various sizes of Burnt Ranch Reservoir.

Yields shown would be in excess of fish requirements and evaporation. The evaporation rate was considered to be 2.40 feet per year.

Following is a table showing flows required from Beartooth Reservoir on the New River and Burnt Ranch Reservoir on the Trinity River to provide for fishery requirement on the Trinity River below the confluence with the New River.

FISH RELEASE FROM BEARTOOTH AND BURNT RANCH RESERVOIRS
MINIMUM FLOW REQUIREMENTS

Month	1 Below Burnt Ranch Dam		2 Below Beartooth		3 On Trinity R. below New R.	
	cfs	1,000 AF	cfs	1,000 AF	cfs	1,000 AF
Oct.	50	3	50	3	150	9
Nov.	50	3	150	9	200	12
Dec.	50	3	150	9	200	12
Jan.	50	3	100	6	150	9
Feb.	50	3	100	6	150	9
Mar.	50	3	100	6	150	9
Apr.	50	3	100	6	150	9
May	50	3	100	6	150	9
June	50	3	100	6	150	9
July	50	3	50	3	150	9
Aug.	50	3	50	3	150	9
Sept.	50	3	50	3	150	9
TOTAL		36		66		114

1. Must be provided under all conditions.

2. Must be provided as long as there is active storage in Beartooth Reservoir, then the natural inflow must be released until inflow rate exceeds required minimum flow.

3. Is provided from Beartooth Reservoir until active storage is depleted, then the difference between the natural flow at Beartooth and minimum flow required below New River is supplied from Burnt Ranch.

Note: The large releases in the fall are sometimes made earlier or later depending on natural runoff patterns.

CHART F: Capital Cost - Gross Storage Data for Eltapom, Burnt Ranch and Beartooth Reservoirs

The cost curves for Eltapom and Burnt Ranch Reservoirs were made by the Northern Branch Design Unit in 1963. The cost curve for Beartooth Reservoir was made by the Planning Section using very rough estimating methods.

The cost estimates of Eltapom Dam and Reservoir include an especially high contingency factor due to the uncertain foundation condition. This factor greatly increases the cost of a high dam at the site.

CHART G: Unit Cost of Active Storage in Eltapom and Burnt Ranch Reservoirs

The dead storage level in Burnt Ranch Reservoir was considered fixed at the streambed elevation of Helena Dam, of 1,285 feet. The slope of the War Cry Tunnel would govern the minimum pool level at Eltapom. This slope would vary slightly with different yields from Eltapom; therefore, the dead storage in Eltapom would vary from 120,000 to 140,000 acre-feet.

CHART H: Size and Cost of New River and War Cry Tunnels

This curve shows the optimum size of both tunnels for various yields, and also the capital cost for various diameters. In selecting the optimum tunnel diameter, consideration was given to the cost of the tunnel and of that particular reservoir from which the tunnel would originate.

The cost of these tunnels are based on estimates made by the Trinity River planning unit.

CHART I: Capital and Annual Cost of Helena Pumping Plant

This curve shows the capital and annual cost of Helena Pumping Plant with various project yields. It was assumed that Helena Reservoir would have a normal pool elevation of 1,837 feet, a minimum pool elevation of 1,650 feet and an average water surface elevation of 1,777 feet. Burnt Ranch Reservoir would have a normal pool elevation of 1,437 feet, a minimum pool elevation of 1,285 feet and an average water surface elevation of 1,371 feet. The actual design head was estimated to be 410 feet.

CHARTS J AND K: Effects of Yield Development at Burnt Ranch Reservoir on Later Staged Pumping Plants on the Trinity River

These charts show the changes in the design head, the annual energy requirement and the annual cost of pumping plants on the Trinity River, that occur when operating Burnt Ranch Reservoir for a given water yield. It was presumed that Helena Reservoir would be constructed to a normal pool elevation of 1,837 feet and the later staged Ironside Reservoir would have a constant pool elevation of 870 feet. Any change in head at either Helena or Burnt Ranch Pumping Plant would be the result of a change in water surface elevation in Burnt Ranch Reservoir.

As the desired yield of Burnt Ranch Reservoir increases, the required dam height increases, so also would the water surface elevation. This in turn would decrease the pumping head on Helena Pumping Plant but would increase the head on the later staged Burnt Ranch Pumping Plant. However, Helena would always pump more water than Burnt Ranch Pumping Plant and the annual energy consumption would decline as the yield and capacity of Burnt Ranch gets larger. The annual cost would also decrease, but only up to yields of 200,000 acre-feet after which the annual cost would increase. This is due to the rapid increase in the combined design head.

Estimates of annual energy and annual cost are based on Burnt Ranch Pumping Plant conveying six million acre-feet annually and Helena Pumping Plant conveying 7.2 million acre-feet annually. Curve B on Chart K is based upon the Helena Pumping Plant conveying 1.2 million acre-feet per year.

CHART L: Optimum Minimum and Normal Water Surface Elevations Vs. Yield of Burnt Ranch or Eltapom Reservoirs

The optimum minimum pool elevation of Eltapom Reservoir was estimated by considering various slopes of War Cry Tunnel for various yields. The lowest combined cost for each yield indicated the proper tunnel slope and diameter, and the proper minimum and normal pool elevations of Eltapom, for that particular yield.

The minimum pool elevation of Burnt Ranch Reservoir would be fixed as being the streambed elevation at Helena Dam. The normal pool elevations of Burnt Ranch Reservoir were found in the usual fashion.

CHART M: Capital Cost of Water Delivered to Helena Reservoir

This chart shows how much capital is required to deliver water to Helena Reservoir from various combinations of Eltapom, Beartooth and Burnt Ranch Reservoirs.

Curve A applies to water from Beartooth and Burnt Ranch Reservoirs on a power schedule. In this plan New River water would be stored in Burnt Ranch Reservoir.

Curve B applies to water from Eltapom Reservoir only. In this plan Burnt Ranch Reservoir serves only as a conveyance reservoir. The yield would be delivered on a power schedule.

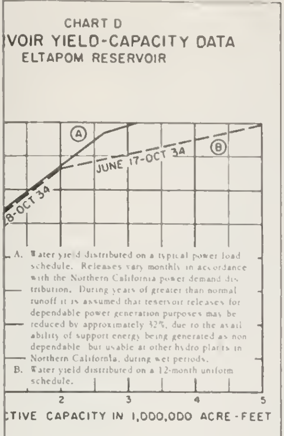
Curve C applies to water from all three reservoirs, but with the yield of Burnt Ranch Reservoir fixed at 200,000 acre-feet. Water would be delivered on a uniform scale.

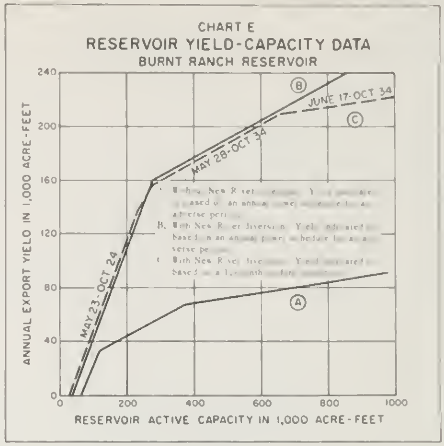
Curve D also applies to water from Burnt Ranch, Eltapom and Beartooth Reservoirs but the yield would be on a power schedule.

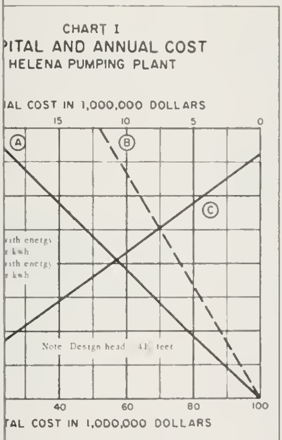
CHART N: Unit Cost of Water Delivered to Helena Reservoir

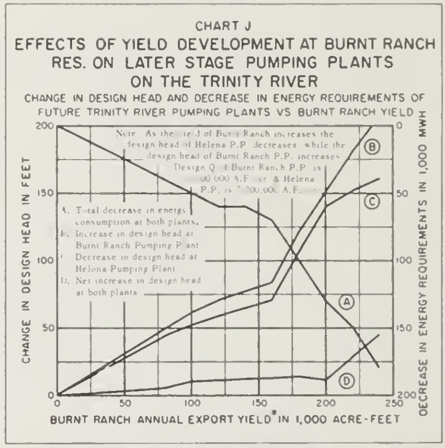
This chart duplicates Chart M except the expression of cost of water developments is in terms of annual unit cost per acre-foot.

Curves A, B, C, and D apply to the same reservoir combinations as in Chart M. For Curve E the annual value of energy for pumping was assumed to be 1.1 mills per kilowatt-hour instead of 3.3 mills as used in the other curves.







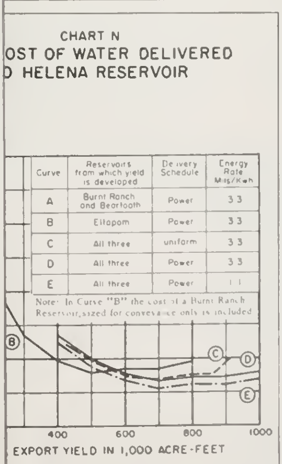


Note All estimates of capital costs include allowances of 15% for contingencies and 15% for engineering and project administration. Estimates of annual costs include annual expenses for operation maintenance and replacement. Capital recovery period is [illegible] years at [illegible] interest.

Water developed on a power schedule has the following monthly distribution:

ADVERSE PERIOD				NORMAL PERIOD			
Oct.	7.6%	Apr.	7.2%	Oct.	5.3%	Apr.	[illegible]
Nov.	6.5%	May	[illegible]	Nov.	5.3%	May	[illegible]
Dec.	6.8%	Jun.	9.9%	Dec.	4.2%	Jun.	[illegible]
Jan.	6.1%	Jul	12.6%	Jan.	[illegible]	Jul.	[illegible]
Feb.	[illegible]	Aug.	[illegible]	Feb.	[illegible]	Aug.	[illegible]
Mar.	8.4%	Sept.	[illegible]	Mar.	4.6%	Sep.	[illegible]
		Total	100.[illegible]			Total	[illegible]

*Indicates yield is on a power schedule



Curve	Reservoirs from which yield is developed	Delivery Schedule	Energy Rate Mills/Kwh
A	Burnt Ranch and Beartooth	Power	3.3
B	Eltapom	Power	3.3
C	All three	uniform	3.3
D	All three	Power	3.3
E	All three	Power	1.1

Note: In Curve "B" the cost of a Burnt Ranch Reservoir, sized for conveyance only is included

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION

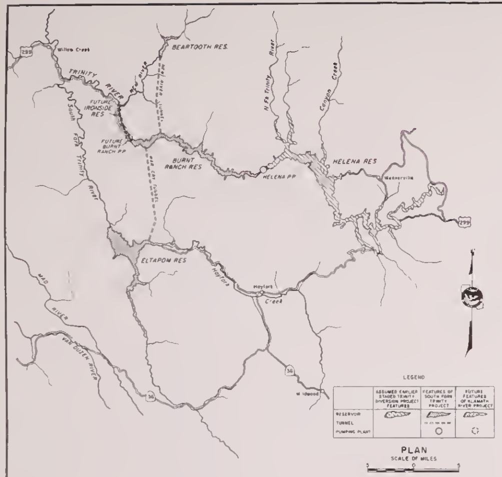
TRINITY RIVER DIVISION

1963

SOUTH FORK TRINITY PUMP PROJECT

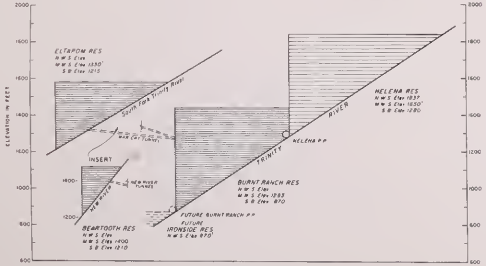
ALTERNATIVE TO S. FK. TRINITY GRAVITY PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES AND CONVEYANCE TO HELENA RESERVOIR WHICH WOULD HAVE A NORMAL AND MINIMUM WATER SURFACE ELEVATION OF 1837 AND 1650 FT RESPECTIVELY



PLAN

SCALE OF MILES



PROFILE

NO HORIZONTAL SCALE

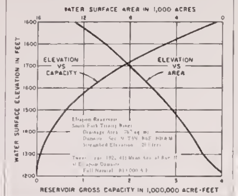


CHART A
ELEVATION-AREA-CAPACITY DATA
ELTAPOM RESERVOIR

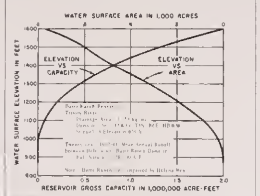


CHART B
ELEVATION-AREA-CAPACITY DATA
BURNT RANCH RESERVOIR

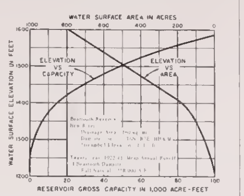


CHART C
ELEVATION-AREA-CAPACITY DATA
BEARTOOTH RESERVOIR

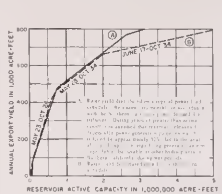


CHART D
RESERVOIR YIELD-CAPACITY DATA
ELTAPOM RESERVOIR

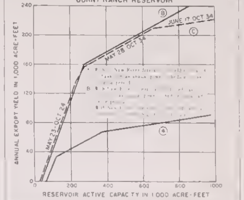


CHART E
RESERVOIR YIELD-CAPACITY DATA
BURNT RANCH RESERVOIR

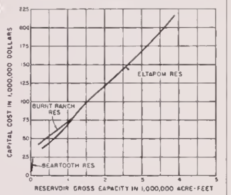


CHART F
RESERVOIR COST-CAPACITY DATA
BEARTOOTH, ELTAPOM AND BURNT RANCH RESERVOIRS

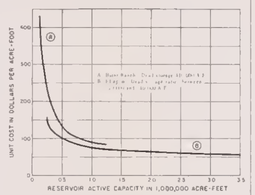


CHART G
UNIT COST OF ACTIVE STORAGE
ELTAPOM AND BURNT RANCH RESERVOIRS

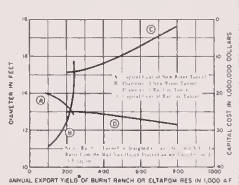


CHART H
CAPITAL COST AND DIAMETER VS YIELD
WAR CRY AND NEW RIVER TUNNELS
LENGTHS 54,000 AND 44,000 FEET RESPECTIVELY

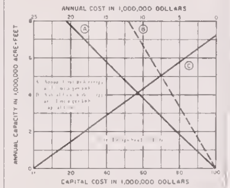


CHART I
CAPITAL AND ANNUAL COST
HELENA PUMPING PLANT

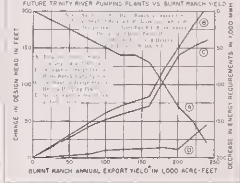


CHART J
EFFECTS OF YIELD DEVELOPMENT AT BURNT RANCH RES. ON LATER STAGE PUMPING PLANTS ON THE TRINITY RIVER
CHANGE IN DESIGN HEAD AND DECREASE IN ENERGY REQUIREMENTS OF FUTURE TRINITY RIVER PUMPING PLANTS VS BURNT RANCH YIELD

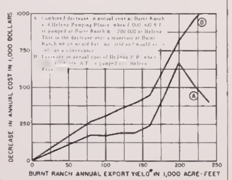


CHART K
EFFECTS OF YIELD DEVELOPMENT AT BURNT RANCH RES ON LATER STAGE PUMPING PLANTS ON THE TRINITY RIVER
DECREASE IN ANNUAL COST OF FUTURE PUMPING PLANTS VS BURNT RANCH YIELD

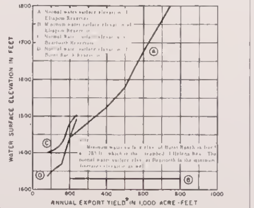


CHART L
OPTIMUM MINIMUM & NORMAL WATER SURFACE ELEVATIONS VS YIELD OF BURNT RCH. OR ELTAPOM RES.

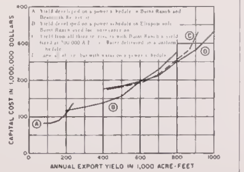


CHART M
CAPITAL COST OF WATER DELIVERED TO HELENA RESERVOIR

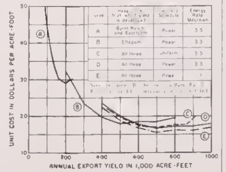


CHART N
UNIT COST OF WATER DELIVERED TO HELENA RESERVOIR

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
TRINITY RIVER DIVISION
1963

SOUTH FORK TRINITY PUMP PROJECT
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RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NEW EXPORTABLE WATER SUPPLIES AND CONVEYANCE TO HELENA RESERVOIR WHICH WOULD HAVE A NORMAL AND MINIMUM WATER SURFACE ELEVATION OF 1837 AND 1650 FT RESPECTIVELY

PLATE 11
MAD-VAN DUZEN PROJECT

The purpose of this plate is to present data to analyze the Mad and Van Duzen Rivers as an addition to the Trinity River Development.

Although there are many damsites on the Mad and Van Duzen Rivers, only six possible reservoirs are discussed in this presentation: Ruth, Anderson Ford, and Butler Valley on the Mad River; Eaton on the Van Duzen River; and Larabee Valley and Base Line on the South Fork of the Van Duzen River.

Butler Valley Reservoir would be a replacement for the existing Ruth Reservoir which serves the Humboldt Bay area and maintains certain required flows below Essexs for fish enhancements.

Base Line Reservoir would be primarily for fish and recreation enhancement on the Van Duzen and Lower Eel Rivers. It would be built as an alternative to Larabee Valley. While it would not serve directly to provide water for export, it would allow increased exports from Eaton Reservoir from water that otherwise would have been released for fish.

Base Line Reservoir appears to have considerable potential as a local project. About a 200-foot dam at the site would create a reservoir which could produce a uniform flow at the junction of the South Fork and Main Stem of the Van Duzen River of about 100 cfs. The flow would be reduced during a period of low runoff such as that during 1923-24, however. The value of the water saved at Eaton might be nearly equal to the cost of Base Line Dam.

Anderson Ford Reservoir would be the forebay to the South Fork Trinity Powerplant which would be located on the shore line of Eltapom. The optimum minimum pool of Anderson Ford Reservoir seems to be about elevation 2,350 for all reasonable yields. The cost of Anderson Ford dam, the tunnel to the South Fork, the penstock, and the powerplant were all considered in determining this. It should be noted, however, that the cost estimate for Anderson Ford is very rough, a slight decrease in cost would move the minimum pool to elevation 2,400 or 2,450 feet.

Yields are shown on the storage-yield charts as being exported on both uniform and power schedules; however, on the succeeding charts, the word "yield" refers to water produced on a power schedule. Actual difference between the amounts of water released on a power schedule and a uniform schedule would be slight except during the long critical periods e.g., 1916 to 1934, etc. This is due to a wet year clause in the assumed power schedule, which would allow a reduction in power output which would in turn reduce the water requirement. The period 1916 to 1934 contains a number of wet years. During these years releases would be reduced to only 68 percent of a dry year requirement.

CHARTS A, B, C, D, E, AND F:

These are area-capacity-elevation charts for all the reservoirs considered: Ruth, Eaton, Larabee Valley, Anderson Ford, Butler Valley, and Base Line.

Data for all site were derived from USGS quadrangles, with a scale of 1:62,500, and with contour interval of 50 and 100 feet.

Storage was computed by the average end area method. The storage Base Line Reservoir was checked by the prismoidal formula.

CHARTS G, H, I, AND J: Storage-Yield Curves

Except for Base Line Reservoir, these curves were derived by a tabular method rather than actual yield studies. Yields were computed on both uniform and power schedules, except for Butler Valley and Base Line Reservoirs which were computed only on a uniform schedule.

For Base Line and Butler Valley Reservoirs, the indicated yield would be at some point well downstream from the reservoir, since these reservoirs would firm up uncontrolled water between the reservoir and the point of diversion. In the case of Butler Valley, this point would be the Essex Pump Diversion Plant; for Base Line Reservoir, this point would be the confluence of the South Fork and the Main Stem of the Van Duzen River.

Yield-capacity curves for combined reservoir operations have been developed by treating these as a single reservoir with more than one inflow. This treatment is possible since minimum size connecting tunnels will handle almost any flow that can be expected. In using this curve, Anderson Ford Reservoir should have at least 70,000 acre-feet of active storage for any large yield.

Evaporation rates which were used are as follows:

Ruth--------------2.5 feet per year
Anderson Ford-----2.3 feet per year
Butler Valley-----1.5 feet per year
Eaton-------------2.3 feet per year
Larabee Valley----2.0 feet per year
Base Line---------2.0 feet per year

It should be noted that 31,000 acre-feet per year would be released from Larabee Valley Reservoir for fish, and 12,000 acre-feet from Anderson Ford Reservoir; therefore, their yields for export would be considerably reduced.

The following table shows the release schedule:

STREAMFLOW MAINTENANCE

Month	Larabee Valley 1/		Eaton		Ruth		Anderson Ford & Butler Valley		Sub-Total 2/	MWD's Point of Diversion at Essex 3/		Total
	cfs	1000 AF	cfs	1000 AF	cfs	1000 AF	cfs	1000 AF	1000 AF	cfs	1000 AF	1000 AF
Oct.	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	40	2.4	5.4
Nov.	50	3.0	5	0.3	5	0.3	16.6	1.0	4.0	62	3.8	7.8
Dec.	67	4.0	5	0.3	5	0.3	16.6	1.0	5.0	75	4.5	9.5
Jan.	67	4.0	5	0.3	5	0.3	16.6	1.0	5.0	75	4.5	9.5
Feb.	50	3.0	5	0.3	5	0.3	16.6	1.0	4.0	75	4.5	8.5
Mar.	50	3.0	5	0.3	5	0.3	16.6	1.0	4.0	75	4.5	8.5
Apr.	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	75	4.5	7.5
May	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	75	4.5	7.5
June	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	75	4.5	7.5
July	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	50	3.0	6.0
Aug.	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	40	2.4	5.4
Sept.	33	2.0	5	0.3	5	0.3	16.6	1.0	3.0	30	1.8	4.8
Total		31.0		(3.6)		(3.6)		12	43.0		45.0	88.0

1/ This would be the release from both Eaton and Larabee Valleys.
2/ This would be the total depletion from the export system.
3/ This would be in excess of 118 cfs required for diversion to Humboldt Bay Municipal Water District.

CHART K: Reservoir Cost-Capacity Data

These curves show the capital cost-gross storage relationship for Ruth, Anderson Ford, Butler Valley, Eaton, and Anderson Ford Reservoirs.

These curves are based on reconnaissance-type estimates prepared by the Design Unit of the Northern Branch. All cost includes 15 percent for engineering and administration, 15 percent for contingencies, and 4 percent interest during construction.

Annual cost while not shown on the chart would be about 4.85 percent of the capital cost.

CHART L: Unit Cost of Active Storage

This curve shows the unit cost of active storage for the four export reservoirs. Also shown is their unit cost when the cost of conveyance to Anderson Ford is included. The size of these conveyance facilities (Larabee Valley-Eaton Tunnel and Eaton-Mad Tunnel) would be at the diameter of minimum cost but would still be capable of conveying the project's total yield.

CHART M: Unit Cost of Water Delivered to Anderson Ford at Elevation 2,350 from Various Reservoirs

This chart shows the relative costs of water development among various reservoirs. It reflects the reservoir costs and the required tunnel cost, if any.

CHART N: South Fork Trinity Power Facilities

This chart shows the capital cost, annual cost, revenue, net revenue, and dependable capacity for a range of yields.

The costs do not include penstocks.

The effective head is fixed at 600 feet which is based on a minimum pool elevation at Anderson Ford of 2,350 feet, with a fixed tunnel length and head loss of 100 feet, and a tailrace elevation of 1,650 feet. Of course, this tailrace elevation hinges on the normal pool elevation of Eltapom which is presently estimated to be about 1,650 feet.

CHART O: South Fork Tunnel Data

This chart shows the diameter and capital cost of the South Fork Tunnel for various yields. As previously stated, the length and slope was assumed fixed, and the minimum pool of Anderson Ford was fixed at 2,350 feet.

A cost curve was made from estimates made by the Design Section of the Northern Branch for a tunnel 36,000 feet long. This cost was scaled down to suit the 25,000-foot tunnel.

CHART P:

These curves show the capital cost of four possible plans for development of the Mad and Van Duzen Rivers. Included in the amounts are:

the cost of reservoirs, including Butler Valley Reservoir which would replace the existing Ruth; the connecting tunnels, if any; the South Fork tunnel and the South Fork penstock; and the South Fork powerplant. In all plans Anderson Ford Reservoir would have 70,000 acre-feet of active storage and a minimum pool elevation of 2,350 feet.

Curve A shows the cost of the full development of the Mad and Van Duzen Rivers. It would include Larabee Valley, Eaton, Ruth and Anderson Ford Reservoirs with Butler Valley Reservoir supplying local water.

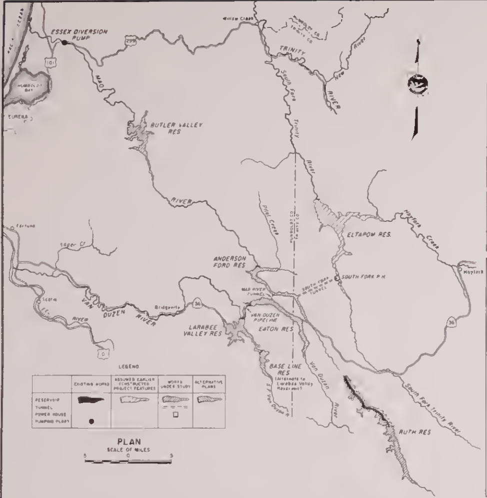
Curve B shows the cost of the development without Larabee Valley Reservoir. The flow of the South Fork would be firmed up from Eaton to maintain fish at the present level.

Curve C shows the cost of the development without Larabee Valley and Ruth Reservoirs. Eaton Reservoir would be operated to "firm up" the water supply from Anderson Ford Reservoir.

Curve D shows the cost of Mad River development only. This would include Ruth and Anderson Ford Reservoirs, with Ruth Reservoir operated to "firm up" Anderson Ford Reservoir.

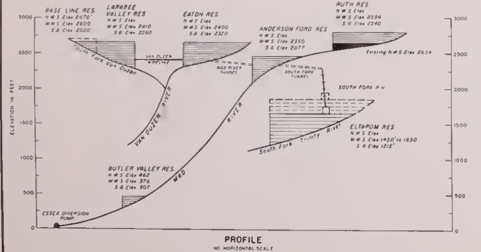
CHART Q:

These data show the unit cost of water delivered to Eltapom Reservoir at elevation 1,650 feet for the four plans as described in Chart P.



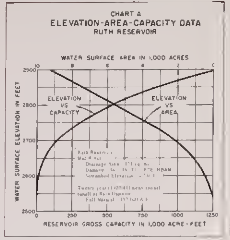
PLAN

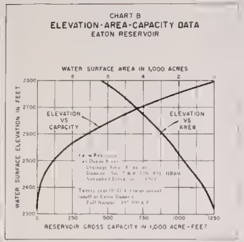
SCALE OF MILES

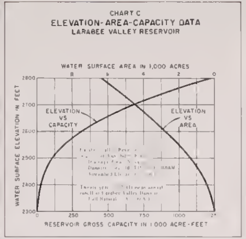


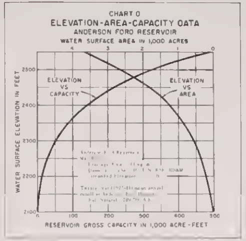
PROFILE

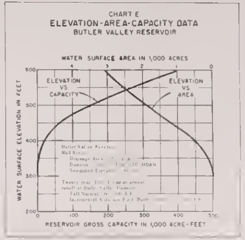
NO HORIZONTAL SCALE

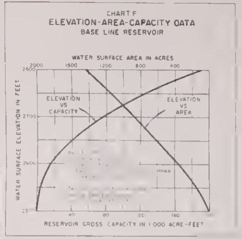


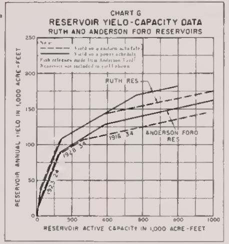


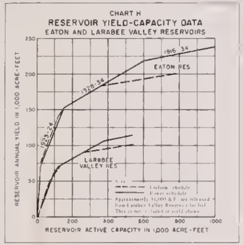


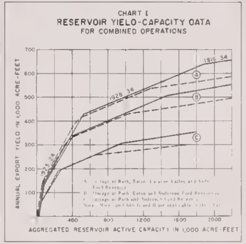


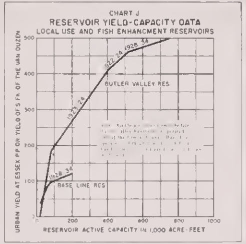


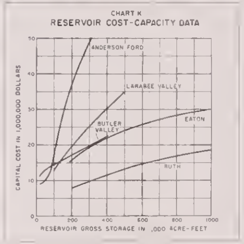


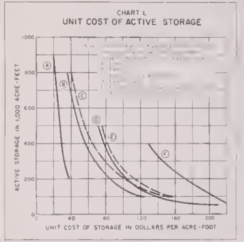


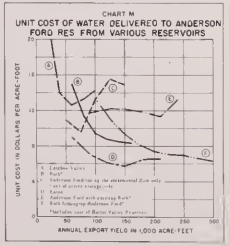


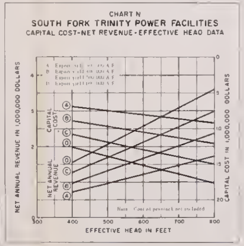


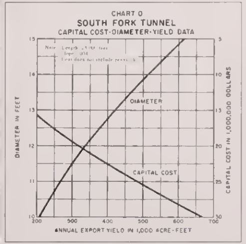


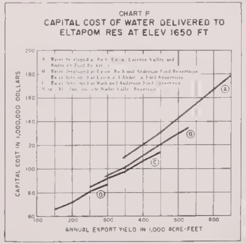


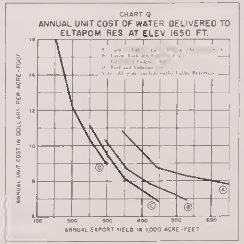












STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION
TRINITY RIVER DIVISION
1963

MAD-VAN DUZEN PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT FEATURES AND EXPORT FACILITIES TO ELTAPOM RESERVOIR, A UNIT OF THE SOUTH FORK TRINITY PROJECT

PLATE 12
THE WEST SIDE CONVEYANCE SYSTEM
Without Trinity River Imports

The purpose of this plate is to outline the possible accomplishments of the West Side Conveyance System as a storage facility and as a diversion to the Glenn Reservoir Complex. The analysis has been carried out both with and without the Middle Fork Eel Diversion as a prior import. Diversions from the Trinity, Mad, and Van Duzen river systems to the Glenn Reservoir Complex, which would be facilitated by the existence of the West Side Conveyance System, may be evaluated and presented on a later plate.

The Glenn Reservoir-West Side Conveyance Systems' accomplishments shown on this plate are based on a uniform monthly distribution of firm annual yield. This is quite probably not the schedule the system would operate on to sustain a firm yield in the Delta. However, for this stage of studies, the uniform schedule provides a convenient basis for comparing alternative projects.

The storage-yield curves shown on this plate were developed for conditions of "Net yield" only. However, the relative accomplishments of the West Side Conveyance System could be determined equally well on the basis of "gross yield". "Gross yields" would be based on conditions of full natural flow, while "net yield" were based on the assumption that the Glenn-West Side System would operate as an increment above the existing and near-future Central Valley Reservoir System. In the latter case it was assumed that the only time water could be stored in the Glenn-West Side System was when that water was not serving a prior beneficial downstream purpose. All present and contemplated near-future water demands of the Orland Project and Black Butte Reservoir were met. In all cases, imports from the Middle Fork Eel River enter Glenn Reservoir on a random schedule, corresponding to the plan of diverting the greatest possible amount of Eel River water in a given time. A more detailed description of "gross yield" and "net yield" is presented in the descriptive memorandum for Plate 3.

This plate summarizes an analysis of the West Side Conveyance System as an adjunct to the Glenn Reservoir Complex. It is based on specific assumptions, which are discussed in the following chart explanations. Any conclusion made on the basis of this plate should be viewed in the full light of the inherent limitations and the assumptions made.

CHART A:

This chart sets forth area-elevation-capacity data for the entire West Side Conveyance System, and is based on a combination of the area-elevation-capacity data for the individual constituent reservoirs. Possible storage capacity obtainable in the interconnecting cuts is not included. All of the data for the individual reservoirs, with the exception of Schoenfield Reservoir, was taken from USGS quadrangle maps; 1:62,500, contour interval of 50 feet. Data for Schoenfield Reservoir are from a DWR map dated 1922, scale: 1-inch = 450 feet, contour interval equals 20 feet.

CHART B:

The chart sets forth area-elevation-capacity data for various elements of Glenn Reservoir Complex which could be used in conjunction with the West Side Conveyance System. These data were developed from the Department of Water Resources' Glenn Reservoir map, dated July 1960, scale: 1-inch = 1,000 feet, contour interval equals 20 feet. This map is available also at a scale of 1-inch = 400 feet.

CHART C:

Chart C is a table showing pertinent data for the West Side Conveyance System. These data are very preliminary and subject to considerable revision.

CHART D:

Chart D presents storage yield-data for Glenn Reservoir and the West Side Conveyance System without any diversions from the Eel or Trinity Rivers. The water supply hydrology of the Glenn Reservoir Complex is discussed in the descriptive memorandum for Plate 3 of this series. Inflow to the West Side Conveyance System is derived from the upper drainage of Cottonwood Creek excluding the North Fork and the upper drainage of Elder Creek. The system may also collect flows from a very minor part of the drainage of Thomes Creek downstream of the proposed Paskenta project. The inflow to the West Side Conveyance System was estimated by use of area-precipitation relationships, using the Cottonwood Creek near Cottonwood gage and the Thomes Creek near Paskenta gage as base stations. For the period prior to the installation of these gages (1915-16 to 1920-21) flows at the gage sites were obtained by correlation with the Sacramento River at Red Bluff.

The storage-yield relationships were corrected for evaporation by use of an empirical expression:

$$C = E \times \left[.66\ (MA - LA) + LA\right]$$

Where,

C = Annual evaporation correction during reservoir critical period of operation

E = Annual evaporation rate (assumed to be 3.0 feet)

MA = Area at maximum pool

LA = Area at minimum pool

The minimum pool was determined by rough estimates of required sedimentation storage.

CHART E:

Chart E is the same analysis as Chart D with the addition of imports from the Middle Fork Eel River. The import is achieved by a 532,000 acre-foot Spencer Reservoir with a 10-foot tunnel. Further details can be found in the descriptive memorandum for Plate 2 of this series.

CHART F:

This chart shows the relationships between reservoir storage capacity and capital and annual cost data for two possible combinations of the components of the Glenn Reservoir Complex. Total annual cost is assumed to equal 5 percent of the capital cost. Further detail regarding these cost estimates is given in the descriptive memorandum for Plate 3 of this series.

CHART G:

Chart G sets forth capital cost-annual firm yield data for the West Side Conveyance System and Glenn Reservoir Comples combined without an import from the Middle Fork Eel. Two curves are shown; one delineates the accomplishments of the West Side Conveyance System with storage available at Paskenta-Newville Reservoir; the other delineates accomplishments if the entire storage of Glenn Reservoir is available. Th features and cost of the West Side Conveyance System were not varied within this study.

CHART H:

This chart presents the same information as Chart G with an import from Spencer Reservoir included.

CHART I:

This chart shows an approximate relationship between net new annual yield attributable to the West Side Conveyance System and storage available in the West Side Conveyance System and/or the Glenn Reservoir Complex. The actual relationship is somewhat more complex than that shown. A more adequate delineation of this storage-yield data could be achieved if the initial project were known in more detail. The limits of net new annual yield attributable to the West Side Conveyance System are shown for various prior conditions of development.

CHART J:

This chart shows the approximate range of unit annual costs for developing net new water yield attributable to the West Side Conveyance System with various conditions of prior development.

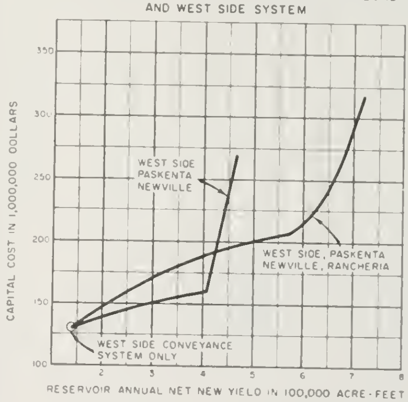
Costs and benefits associated with flood control, hydro-power, recreation, and fisheries enhancement are not included in this analysis. The data shown do not reflect costs associated with construction of the proposed highway from the vicinity of Orland to the vicinity of Willits via the Mendocino Pass route. A bridge across the Chrome Channel portion of the Glenn Reservoir Complex probably would be required for this highway, and its cost would be assigned to the project.

The relationships shown on the above charts are very sensitive to changes in cost data. Since these data are currently under study, conclusions should be viewed in the light of this fact and other assumptions made. The applicability of the assumption of operation on a uniform yield basis is discussed in the descriptive memorandum which concerns Plate 3 of the series.

CHART C
DATA TABLE - WEST SIDE CONVEYANCE SYSTEM

RESERVOIR	STREAM	DAM SITE LOCATION	DRAINAGE AREA Sq Mi	STREAMBED ELEVATION Ft	MAXIMUM WS ELEVATION Ft	[illegible] ELEVATION Ft	STORAGE BELOW [illegible] AF	[illegible] $
FIDDLERS	MIDDLE FORK COTTONWOOD CR	Sec 28 T29N, R7W	208	750	[illegible]16	979	15[illegible]	44
PENTACOLA	DRY CREEK	Sec 10 T28N, R7W	64	865	[illegible]6	977	6[illegible]	4
LITTLE PENTACOLA	—	Sec 10 T28N, R7W	2	890	[illegible]14	975	[illegible]5	
MEADOW GULCH	—	Sec 22 T28N, R7W	5	880	,012	972	[illegible]5	4
SAUNDERS FLAT	SALT CREEK	Sec 26 T28N, R7W	34	775	[illegible]8	91,9	35	45
TRUEBLOOD GROUP	—	Sec 35 T28N, R7W	3	900	[illegible]007	967	[illegible]8	
LONG GULCH	—	Sec 3 T28N, R6W	4	920	[illegible]5	965	3.2	[illegible]9
COLD FORK	COLD FORK CR	Sec 7 T27N, R6W	61	850	1,007	962	8.5	36
GUYRE CREEK	GUYRE CREEK	Sec 17 T27N, R6W	10	830	1,005	960	[illegible]2	[illegible]0
McCARTNEY	SOUTH FORK COTTONWOOD C[illegible]	Sec 21 T27N, R6W	130	790	1,001	957	33[illegible]	55
BLUEDOOR	NORTH FORK REDBANK CR	Sec 4 T26N, R6W	8	890	995	954	[illegible]0	34
SCHOENFIELD	REDBANK CR	Sec 16 T26N, R6W	47	730	988	952	98[illegible]	4
GALATIN	ELDER CREEK	Sec 14 T23N, R6W	96	720	982	945	26[illegible]	7[illegible]
CAT RIDGE	McCARTY CR	Sec 30 T24N, R6W	14	930	976	945	6[illegible]	36
DIGGER CREEK	DIGGER CREEK	Sec 30 T24N, R6W	7	930	970	945	58	

CHART G
CAPITAL COST - NET NEW ANNUAL YIELD DATA
INFLOW DERIVED FROM STONY AND THOMES CREEKS AND WEST SIDE SYSTEM



NOTES FOR CHART C

WESTSIDE CONVEYANCE

Total Drainage Area
693 Sq Mi

Total Storage Below Cuts
654,3[illegible]0 A F

Total Capital Cost Of Reservoirs
63,000,000 Dollars

Total Capital Cost Of Cuts
67,000,000 Dollars

Total Capital Cost
[illegible]30,000,000 Dollars

Equivalent Annual Cost
6,500,000 Dollars

The Channels Between Reservoirs Were Designed To Carry The Standard Project Flood Peak Plus 10,000 C F S

Note

The new firm yield potential and costs for alternative Middle Fork Eel River diversion projects and for various elements of the [illegible] are presented on [illegible] of this series.

Yield data as indicated is referenced to the independent project and does not include consideration of the additional yield potential which may be credited to the development through its coordinated operation with the Central Valley Reservoir System.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
SACRAMENTO VALLEY DIVISION
1962

THE WEST SIDE CONVEYANCE SYSTEM WITHOUT TRINITY RIVER IMPORTS

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NET NEW FIRM WATER YIELD AT SITE

RESERVOIR INFLOWS DERIVED FROM NATURAL TRIBUTARY RUNOFF, RUNOFF ABOVE WEST SIDE CONVEYANCE SYSTEM AND IMPORTS FROM MIDDLE FORK EEL RIVER

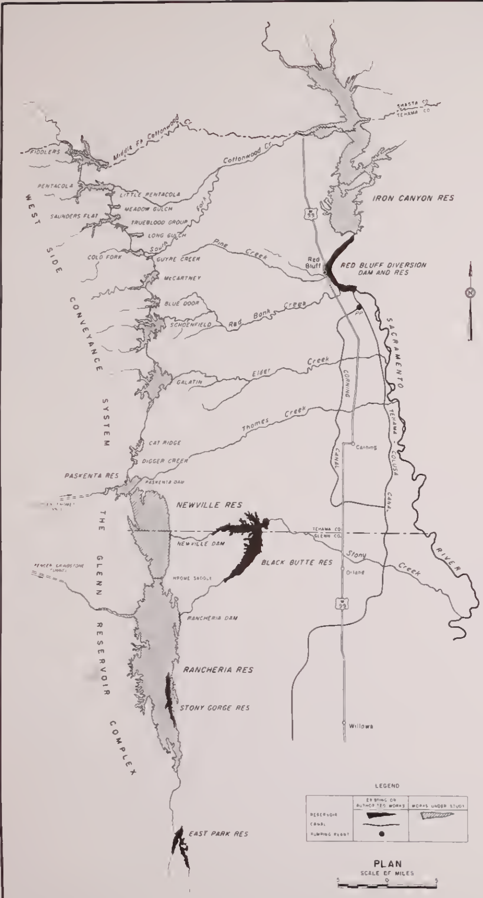


CHART A
AREA-ELEVATION-CAPACITY DATA
WEST SIDE CONVEYANCE SYSTEM

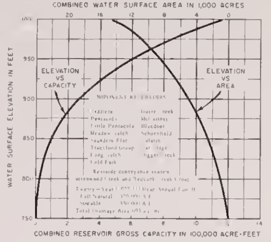


CHART B
AREA-ELEVATION-CAPACITY DATA
GLENN RESERVOIR COMPLEX

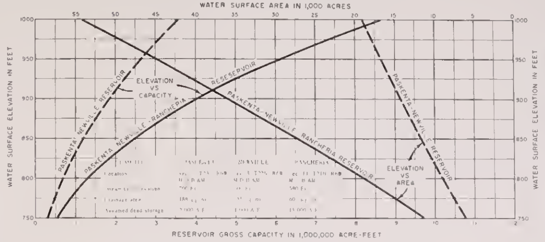


CHART C
DATA TABLE - WEST SIDE CONVEYANCE SYSTEM

RESERVOIR	STREAM	DAM SITE LOCATION	DRAINAGE AREA Sq Mi	STREAM BED ELEVATION Ft	MAXIMUM WS ELEVATION Ft	EXIT CUT ELEVATION Ft	STORAGE BELOW CUT 1,000 A F	CAPITAL COST $1,000,000
FIDDLERS	MIDDLE FORK COTTONWOOD CR	Sec 28 T29N, R7W	208	750	1,016	979	150	14.4
PENTACOLA	DRY CREEK	Sec 10 T28N, R7W	64	865	1,016	[illegible]	61.0	11.4
LITTLE PENTACOLA	—	Sec 10 T28N, R7W	2	890	1,014	975	0.5	[illegible]
MEADOW GULCH	—	Sec 22 T28N, R7W	5	880	[illegible]	972	0.5	4
SAUNDERS FLAT	SALT CREEK	Sec 26 T28N, R7W	34	775	1,008	969	55	4.5
TRUEBLOOD GROUP	—	Sec 35 T28N, R7W	3	900	1,007	967	0.8	1
LONG GULCH	—	Sec 31 T28N, R6W	4	920	1,005	965	3.2	3.9
COLD FORK	COLD FORK CR	Sec 7 T27N, R6W	61	850	1,007	962	8.3	3.6
GUYRE CREEK	GUYRE CREEK	Sec 17 T27N, R6W	10	850	1,005	960	2	[illegible]
McCARTNEY	SOUTH FORK COTTONWOOD C	Sec 21 T27N, R6W	130	790	1,001	957	[illegible]	5.5
BLUEDOOR	NORTH FORK REDBANK CR	Sec 4 T26N, R6W	8	890	995	954		3.4
SCHOENFIELD	REDBANK CR	Sec 6 T26N, R6W	47	730	988	952	98	[illegible]
GALATIN	ELDER CREEK	Sec 14 T25N, R6W	96	720	982	945	260	[illegible]
CAT RIDGE	McCARTY CR	Sec 30 T24N, R6W	14	930	976	945	[illegible]	[illegible]
DIGGER CREEK	DIGGER CREEK	Sec 30 T24N, R6W	[illegible]	930	[illegible]	945	5.8	

CHART D
ANNUAL WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM STONY AND THOMES CREEKS AND WEST SIDE SYSTEM ONLY

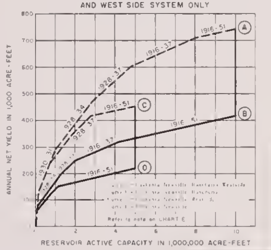


CHART E
ANNUAL WATER YIELD-STORAGE CAPACITY RELATIONSHIPS
INFLOW DERIVED FROM STONY AND THOMES CREEKS, WEST SIDE SYSTEM, PLUS IMPORTS FROM MIDDLE FORK EEL RIVER

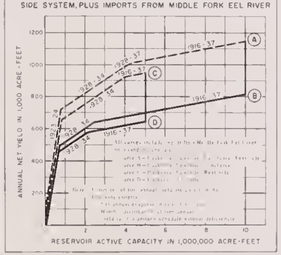


CHART F
RESERVOIR COST-STORAGE CAPACITY DATA
GLENN RESERVOIR COMPLEX

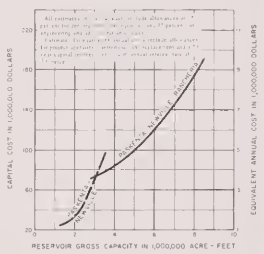
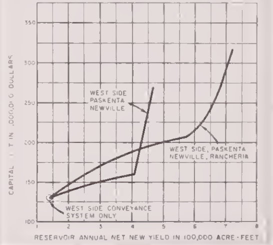


CHART G
CAPITAL COST-NET NEW ANNUAL YIELD DATA
INFLOW DERIVED FROM STONY AND THOMES CREEKS AND WEST SIDE SYSTEM



NOTES FOR CHART C

CHART H
CAPITAL COST-NET NEW ANNUAL YIELD DATA
INFLOW DERIVED FROM STONY AND THOMES CREEKS, WEST SIDE SYSTEM, PLUS IMPORTS FROM MIDDLE FORK EEL RIVER

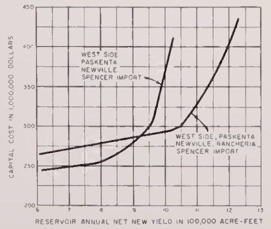


CHART I
ANNUAL NET WATER YIELD ATTRIBUTABLE TO THE WEST SIDE CONVEYANCE SYSTEM

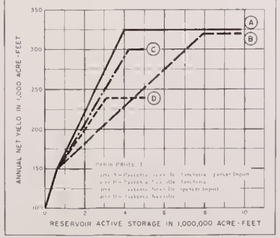
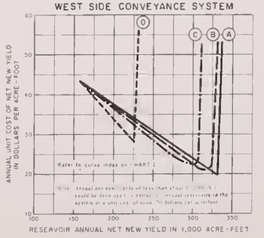


CHART J
ANNUAL COST OF NET NEW WATER YIELD ATTRIBUTABLE TO THE WEST SIDE CONVEYANCE SYSTEM



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION
SACRAMENTO VALLEY DIVISION
1962

THE WEST SIDE CONVEYANCE SYSTEM WITHOUT TRINITY RIVER IMPORTS

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT OF NET NEW FIRM WATER YIELD AT SITE

RESERVOIR INFLOWS DERIVED FROM NATURAL TRIBUTARY RUNOFF, RUNOFF ABOVE WEST SIDE CONVEYANCE SYSTEM AND IMPORTS FROM MIDDLE FORK EEL RIVER

PLATE 13 . . . . Deleted

PLATE 14
KNIGHTS VALLEY PROJECT

The primary purpose of the proposed Knights Valley Project is to develop a firm water supply which could alleviate irrigation and urban demands within Sonoma, Napa, and Marin Counties. The proposed Knights Valley Reservoir could provide off-stream storage for some of the surplus flows which occur frequently in the Russian River in addition to storing most of the natural runoff of Maacama and Franz Creeks.

The initial step undertaken in this investigation was to determine the amounts of surplus flow in the Russian River at the selected sites for diversion during the historical period of 1917-1951. It was assumed that Warm Springs Reservoir, at 277,000 acre-feet of gross capacity, on Dry Creek, along with the existing Coyote Valley Reservoir on the East Fork of the Russian River, would be in operation.

Operation studies which indicate the releases and spills of Coyote Valley and Warm Springs Reservoirs were obtained from the U. S. Corps of Engineers in San Francisco. It was necessary, however, to extend the operation studies in order to include the period of 1917-1922. The monthly outflows of the Russian River at Guerneville, after the firm yields attributed to Coyote Valley and Warm Springs Reservoirs have been diverted, were obtained from the USCE Interim Report, "Russian River California, Dry Creek Basin, Appendix A", revised May 1961. The monthly outflow quantities at Guerneville were reduced by 7,700 acre-feet (equivalent to the mandatory outflow requirements of 125 cfs) in order to determine the surplus flow in the river. These surplus flows had to be readjusted, however, by the amount of natural runoff of Maacama and Franz Creeks which would be retained in Knights Valley Reservoir.

It was considered that the monthly divertable surplus flow at each diversion site could not exceed the monthly surplus flow at Guerneville, and it obviously could not exceed the impaired flow of the river at the site. The impaired flows of the Russian River at the selected sites for diversion were determined as follows:

A. Near Cloverdale: The proposed diversion site would be upstream of the junction of Big Sulpher Creek and the Russian River. The divertable quantities, however, were based on the surplus flows below the junction since it was assumed that the Cloverdale-Knights Valley conveyance system would divert the Big Sulphur Creek surplus flows also. The impaired flows of the Russian River were computed by adding the accretions between Coyote Valley Reservoir and Cloverdale (basic data obtained from the Bay Area Branch) to the spills and releases from Coyote Valley Reservoir.

B. Near Geyserville: The proposed diversion site would be approximately 3.5 miles northwest of Geyserville. It was considered in this investigation that the surplus flows of the Russian River at this site would be the same as at the Cloverdale site (including Big Sulphur Creek flows).

C. Near Healdsburg, immediately below the Maacama Creek Junction: The natural accretions between Coyote Valley Reservoir and Healdsburg (basic data obtained from the Bay Area Branch) were added to the releases and spills from Coyote Valley Reservoir. It was assumed that any flows of Maacama and Franz Creeks which would not contribute to yield from Coyote Valley or Warm Springs Reservoirs or to the mandatory outflow requirement of 125 cfs at Guerneville would be stored in the proposed Knights Valley Reservoir and were not included in the Russian River flows.

The full natural flows of Maacama and Franz Creeks were computed by the North Coastal Area Investigation Unit in August 1961.

The relationships between the capacity of a proposed diversion system and the percentage of the monthly runoff which could be diverted, when an allowance is made for the daily fluctuations of flow in the Russian River, were computed by the Eel River Planning Unit as follows:

Diversion System Capacity in Percent of the Mean Monthly Flow	Quantity of Divertable Water in Percent of the Total Monthly Flow
50	40
100	59
200	78
300	88
400	94
500	98
600	100

The alternative conveyance systems which were investigated have the following basic features:

A. Cloverdale Diversion

1. Cloverdale Diversion Dam - N.W.S. elev. 350 feet
2. Cloverdale-Maacama Canal, L = 37.8 miles
3. Big Sulphur Creek Diversion Dam - N.W.S. Elev. 348 feet
4. Maacama Forebay - N.W.S. Elev. 320 feet
5. Knights Valley Reservoir Pumping Plant

B. Geyserville Diversion

1. Geyserville Divserion Dam - N.W.S. Elev. 240 feet
2. Geyserville-Maacama Canal, L = 1713 miles
3. Maacama Forebay - N.W.S. Elev. 235 feet
4. Knights Valley Reservoir Pumping Plant

C. Healdsburg Diversion

1. Healdsburg Diversion Dam - N.W.S. Elev. 140 feet
2. Intake channel, L = 3.9 miles
3. Knights Valley Reservoir Pumping Plant

The concluding charts on this plate indicate the capital cost versus annual yield relationships and the annual unit cost versus annual yield relationships of water available in Knights Valley Reservoir from imports by the alternative conveyance systems, plus natural runoff.

All estimates of Capital Cost include an allowance of 15 percent for contingencies and 15 percent for engineering and administration. Estimates of equivalent annual cost include annual charges of operation, maintenance, and replacement, and a 50-year capital recovery period at 4 percent interest.

Description of Data

CHART A: Area Capacity Data - Knights Valley Reservoir

These data were developed for the proposed reservoir which would be formed by a dam at streambed elevation 215 feet on Maacama Creek (Sec. 9, T9N, R8W, MDB&M) and by a dam at streambed elevation 265 feet on Franz Creek which would be located in Sec. 23, T9N, R8W, MDB&M.

The water surface elevation versus area data were determined by planimetering the USGS quadrangles Mount St. Helena and Mark West Springs, scale 1:24,000, at contour lines which were plotted at intervals of 40 feet. The average area method was used to compute the elevation versus capacity data.

CHARTS B AND C: Reservoir Yield-Capacity Data

These data indicate the firm yield versus active storage relationship of the project with the indicated diversion system from the Russian River at varying capacity.

The following pattern of distribution, which is based on serving 75 percent irrigation and 25 percent urban demands as published in the Department of Water Resources Bulletin No. 2, Page 95, was used in developing these yield-capacity data:

Oct.	11.3%	Apr.	4.0%
Nov.	5.3%	May	8.8%
Dec.	2.3%	Jun.	15.9%
Jan.	1.8%	Jul.	16.4%
Feb.	2.2%	Aug.	13.9%
Mar.	2.7%	Sep.	15.4%

In computing evaporation losses, it was considered that the reservoir minimum water surface elevation would be 350 feet and the mean net evaporation rate would be 2.5 feet per year.

The mandatory sustained release to Maacama Creek fisheries was considered to be 10 cfs.

The relationship between active storage capacity and firm water yield in Knights Valley Reservoir developed from natural runoff combined with imported flows from the Russian River are summarized as follows:

Active Reservoir Storage in Acre-Feet	Estimated Annual Yield in Acre-Feet Per Year for Diversion Capacity in Cubic Feet Per Second of:			
	500	1000	2000	3000
A. Diversion Point Near Cloverdale or Geyserville				
200,000	135,000	160,000	170,000	175,000
400,000	168,000	208,000	240,000	252,000
600,000	189,000	218,000	275,000	297,000
800,000	196,000	224,000	300,000	323,000
1,000,000	203,000	231,000	330,000	350,000
B. Diversion Point Near Healdsburg				
200,000	133,000	160,000	172,000	177,000
400,000	168,000	211,000	247,000	262,000
600,000	191,000	240,000	289,000	311,000
800,000	199,000	266,000	316,000	341,000
1,000,000	206,000	275,000	343,000	369,000

CHART D: Reservoir Cost-Capacity Data

These data were developed from a cost estimate of Knights Valley Reservoir at a normal water surface elevation of 430 feet (gross capacity of 220,000 acre-feet) prepared by the Northern Branch Design Unit in May 1963, and from a cost estimate of the reservoir at N.W.S. elevation 605 feet (gross capacity of 1,500,000 acre-feet) prepared by the U. S. Corps of Engineers in September 1963. The following items are included:

1. Maacama Dam, spillway, and outlet works
2. Franz Dam and outlet works
3. Reservoir right of way and clearing
4. Channel cutting the divide between Franz and Maacama Creeks with the invert elevation cut 5 feet below the reservoir normal water surface. This connecting channel would not be required if the reservoir normal water surface elevation exceeds 430 feet.
5. Road relocations

CHART E: Diversion Facilities Cost-Capacity Data

These data were developed from cost estimates which were prepared by the North Coastal Area Investigations Unit. The costs of all items of the alternative conveyance systems are included with the exception of the Knights Valley Reservoir pumping plant.

The Cloverdale-Maacama Canal and the Geyserville-Maacama Canal cost estimates were based on a concrete lined trapezoidal section. The Healdsburg intake channel cost estimates were based on an unlined trapezoidal section.

CHARTS F, G, AND H: Pumping Plant Cost-Capacity Data

These data were developed from cost estimates of the Knights Valley Reservoir pumping plant which were prepared by the North Coastal Area Investigations Unit. The cost estimates were based on a plant capable of pumping its rated capacity in cfs against the mean average water surface elevation of the reservoir during a critical period. In this reconnaissance level investigation, the minimum water surface elevation of the reservoir was considered to be 350 feet in all instances. The estimates included the costs of the basic plant, discharge pipe, and electrical substation.

CHARTS I, J, AND K:

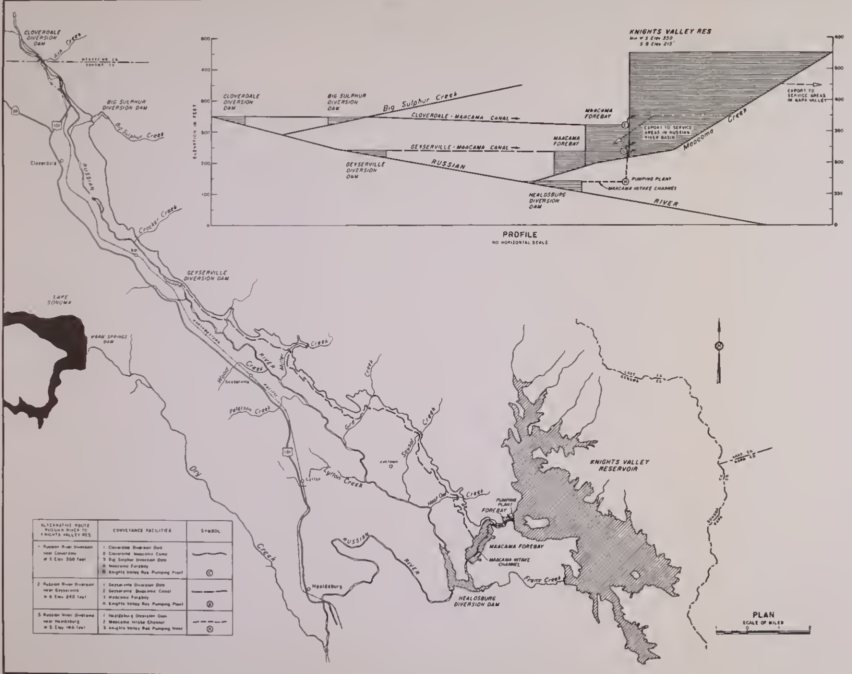
These data which were assembled from the previously described charts indicate the capital cost versus annual yield relationships of the alternative projects with the Russian River diversion systems at varying capacities.

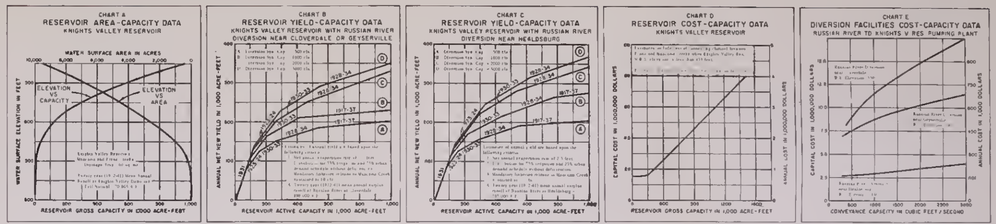
CHARTS L, M, AND N:

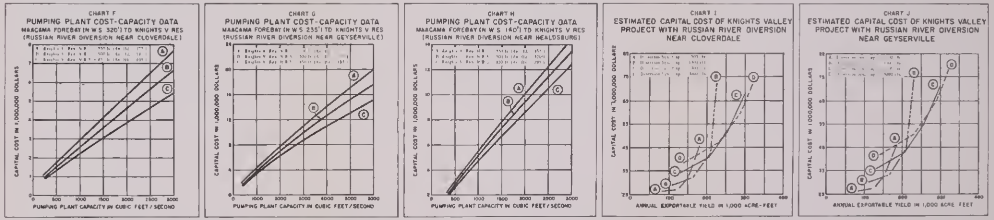
These data which were partially assembled from the previously described charts indicate the annual unit cost versus annual yield relationships of the alternative projects with the Russian River diversion system at varying capacities. The Knights Valley Reservoir pumping plant annual cost was considered to consist of repayment, operation and maintenance, and electrical charges as follows:

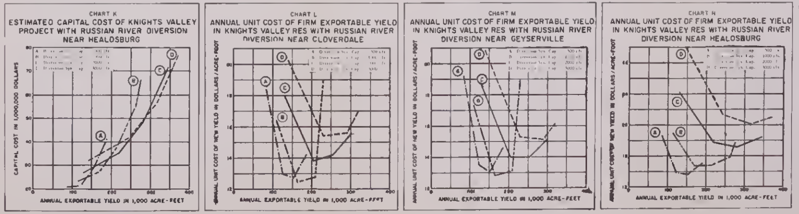
1. Pumping plant capacity per kilowatt year - $30.00
2. Pumping plant energy per kilowatt hour - 3.3 mills. In computing the pumping plant energy requirement, it was estimated that 75 percent of the project annual yield would be pumped into Knights Valley Reservoir during an average year, and 25 percent would be developed from natural runoff.

The diversion system originating near Geyserville would terminate in the Maacama Forebay which would have a N.W.S. elevation of 235 feet and a gross capacity of 14,500 acre-feet. An off-peak pumping schedule was used to size and evaluate this proposed diversion system. Off-peak pumping was not used in the alternative plans with the Russian River Diversion works near Healdsburg or Cloverdale, due to insufficient capacity in the pumping plant forebays.









STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
RUSSIAN RIVER DIVISION
1964

KNIGHTS VALLEY PROJECT

ALTERNATIVE SECOND STAGES

RECONNAISSANCE SUMMARY OF NEW WATER YIELD ACCOMPLISHMENTS AND COSTS WITH RUSSIAN RIVER SURPLUS FLOWS DIVERTED TO THE RESERVOIR

PLATE 15
ALTERNATIVE PLANS FOR DEVELOPMENT OF THE
MIDDLE FORK EEL RIVER - PLAN A
Water Developed in Jarbow and Spencer Reservoirs
Diverted to English Ridge Reservoir

The purpose of this plate is to summarize costs and other pertinent data related to diversion of Middle Fork Eel River flows to English Ridge Reservoir. A basic assumption in the development of this plate was that Round Valley would be protected from inundation.

Five possible reservoirs were considered in the plan of a pumped diversion from the Middle Fork Eel to English Ridge Reservoir. They are: Spencer, Jarbow, Elk Creek, Etsel, and Dos Rios. Spencer, Jarbow, and Elk Creek Reservoirs were studies in the plan presented on Plate 15. Etsel Reservoir could serve as an alternative to Spencer Reservoir and will be studied when cost data become available. Dos Rios Reservoir, which could serve as an alternative to Jarbow Reservoir, is discussed in the descriptive memorandum for Plates 16 and 17.

The plan presented on this plate is based on "on peak" or continuous pumping which is equivalent to delivery of water on a uniform monthly schedule.

Plate 17 presents an analysis of a gravity diversion and a pumped diversion from the Middle Fork to English Ridge Reservoir, under the assumption that Round Valley would be inundated.

CHART A:

Chart A presents area-elevation-capacity data for Jarbow Reservoir. These data were developed from reservoir maps with a scale of 1-inch = 1,000 feet and a contour interval of 20 feet, dated February 1950.

CHART B:

This chart presents area-elevation-capacity data for Spencer Reservoir. These relationships were developed from the Department of Water Resources' Upper Etsel Reservoir map, dated January 7, 1959. The scale of this map is 1-inch = 400 feet, and the coutour interval is 20 feet.

CHART C:

This chart presents area-elevation-capacity data for Elk Creek Reservoir. This information was developed from the USGS Eden Valley quadrangle, scale 1:62,500, contour interval of 100 feet.

CHART D:

Chart D presents firm water yield-storage capacity relationships of reservoirs studied on the Middle Fork Eel River. Curve A delineates the storage-yield relationship for Spencer Reservoir. Inflows were developed from correlation with existing record of natural inflows. Natural flows were depleted by 26,000 acre-feet for local irrigation needs. Curve B represents the storage-yield relationship for Jarbow Reservoir. Inflows were developed by a combination of correlation and area-precipitation methods. Natural flows were depleted by 54,000 acre-feet for fisheries enhancement and 26,000 acre-feet for consumptive use in Round Valley. Curve C presents the storage-yield relationship for Elk Creek Reservoir. It is based on full natural flows which were developed by area-precipitation methods. Curve D presents a storage-yield relationship for the accretions between Spencer and Jarbow Reservoirs. These accretions were depleted by fish releases of 54,000 acre-feet yearly. For a total active storage in Spencer and Jarbow Reservoirs of less than 760,000 acre-feet, Curve B is applicable to both reservoirs. In this size range, Spencer Reservoir has less control of its inflow than Jarbow Reservoir has of the accretions between Spencer and Jarbow Reservoir. A total active system storage of 760,000 acre-feet corresponds to an active storage of 590,000 acre-feet in Spencer Reservoir. For total active storages in excess of 760,000 acre-feet, the yield is a sum of yields shown on Curves A and D. Jarbow Reservoir is limited to a gross storage of 290,000 acre-feet which is equivalent to an active storage of 170,000 acre-feet, in order to prevent extensive inundation of Round Valley.

CHART E:

Chart E presents estimated capital and annual cost-storage capacity relationships. The curve for Elk Creek Reservoir is based on estimates for gross capacities of 145,000, 330,000, and 605,000 acre-feet. The normal water surface elevations corresponding to these capacities are: 1,500, 1,600, and 1,700 feet, respectively. Only one estimate was available for Jarbow Reservoir in the size range considered here. This point is at 290,000 acre-foot gross storage which is equivalent to 170,000 acre-foot active storage. Cost estimates for Spencer Reservoir are available for gross storages of 300,000, 500,000, 580,000, and 700,000 acre-feet. Inactive storage is 20,000 acre-feet. Estimates for capital costs of Jarbow and Spencer Reservoirs include allowances of 15 percent for contingencies, and 15 percent for engineering and project administration charges. Cost estimates of Elk Creek Reservoir include 20 percent for contingencies, and 15 percent for administration and engineering charges. Estimates for equivalent annual costs include allowances for project operation, maintenance, replacement, and 50-year capital recovery period at 4 percent interest.

Of the cost estimates herein delineated, Spencer Reservoir is the most detailed, and is based on the most detailed geologic information. Cost estimates for Etsel Reservoir are currently under preparation.

CHART F:

Chart F presents the relationship between the annual unit costs of exportable yield referenced to the reservoir in which it would be developed and the annual amount of exportable yield. The curve for the cost of water developed in Elk Creek Reservoir is not presented because of scale problems. It was found that the lowest unit cost of water developed in Elk Creek Reservoir would be in excess of $30 an acre-foot. This cost exceeds the cost of developing water in a lower reservoir and pumping it to the elevation of Elk Creek Reservoir. For yields of less than 470,000 acre-feet, the yield is based on the combined storage of Jarbow and Spencer Reservoirs applied to the runoff of the Jarbow site. This is represented by Curve B on Chart D. For yields of more than 470,000 acre-feet, a weighted average of cost resulting from Curve A and Curve D on Chart D was used.

CHART G:

This chart presents the estimated costs versus tunnel diameter for a tunnel from Jarbow Reservoir to English Ridge Reservoir. This cost is independent of the size of English Ridge Reservoir. Penstock, intake, and surge tank costs were assumed to be 20 percent of the tunnel costs. Tunnel costs were developed by the Design Unit of the Northern Branch from reconnaissance geologic data in accordance with their standard cost estimating procedures. It was assumed that the tunnel would be concrete lined and supported for its entire length of 7.5 miles.

CHART H:

This chart presents a comparison of conveyance system costs for an off-peak pumping system and a continuous pumping system. A capacity factor of 50 percent was used for off-peak pumping analyses. Operation on an off-peak basis necessitates over-installation of pumping plants and larger tunnels than would otherwise be required. This is the cause of the higher capital cost shown for an off-peak pumping system. The small difference in annual costs shown is due to a variety of factors. One of these is the capacity charge for power. The cost of power for continuous pumping was assumed to be $30 per kilowatt. A transmission charge of $2.90 per kilowatt was calculated for off-peak power. Although the annual cost for an off-peak system appears to be slightly less than that for a continuous system, a continuous pumping system was used in the analysis of conveyance cost that follows.

CHART I:

This chart presents the estimated costs of pumping plant and appurtenant facilities related to conveyance capabilities. This chart includes the cost of powerplant and substation. Pumping plant costs were developed from USBR's Appendix A data for powerplants. Annual costs of substations and pumping plants and capital costs of substations were taken from curves developed from Federal Power Commission data by the Northern Branch of the Department of Water Resources. These costs do not include charges for pumping power and energy.

CHART J:

This chart shows the relationship between estimated annual costs for power and energy and conveyance capacity. A fixed relationship between conveyance capacity and tunnel diameter was assumed and is shown on the chart. The value of energy was assumed to be three mills per kilowatt hour. The cost of power was assumed to be $30 per kilowatt. These figures are under study.

CHART K:

This chart shows the relationship between total annual and capital costs of conveyance and conveyance capability. The costs of tunnel, pumping plant, substation, penstock, surge tank, and intake s structures are included in the capital cost. These costs contain a factor of 15 percent for engineering and administration, and 15 percent for contingencies. Annual costs include the capital recovery and annual operation, maintenance, replacement, and general expense for the above items, plus the annual charges for power and energy.

CHART L:

Chart L presents the estimated unit costs of conveying water from Jarbow Reservoir to English Ridge Reservoir. This chart includes all costs of conveyance to four different elevations of English Ridge Reservoir.

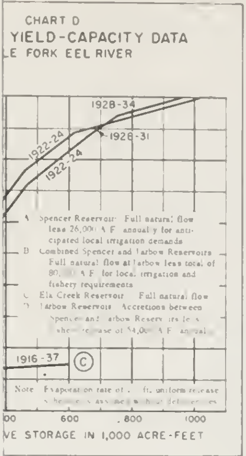
CHART M:

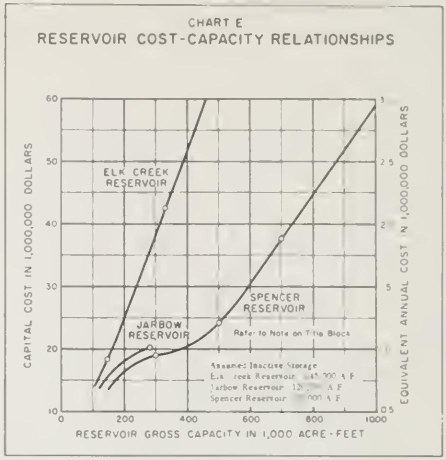
Chart M presents the capital cost-annual yield data for the entire system. This would include the capital costs of Spencer and Jarbow Reservoirs and all conveyance facilities. Only one curve is shown, although the capital costs vary somewhat with the size of English Ridge Reservoir. This variation is not, however, large enough to be shown on this scale.

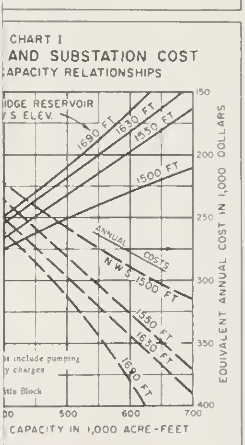
CHART N:

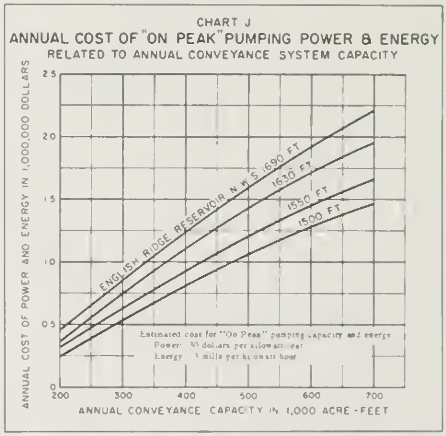
Chart N shows the unit costs of annual exportable yield delivered to various sizes of English Ridge Reservoir. The optimum cost for developing water and exporting it to English Ridge Reservoir is in the \$10.50 to \$12.00 range for nearly all possible sizes of English Ridge Reservoir. This optimum yield-cost relationship takes place at a yield of 440,000 acre-feet.

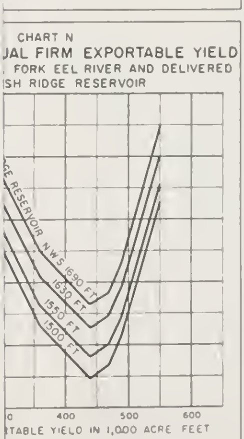
The relationships shown on the above charts are very sensitive to changes in cost data. Since these data are currently under study, conclusions should be viewed in the light of this fact and other assumptions made.











STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION

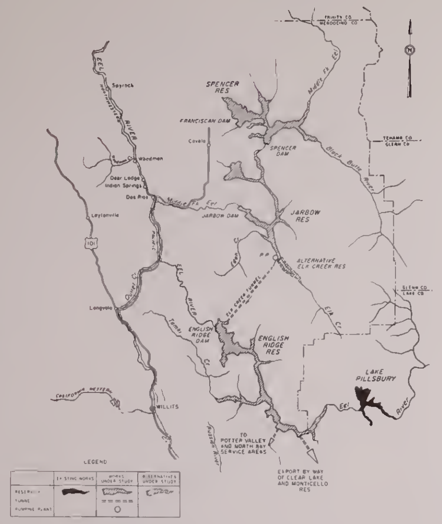
UPPER EEL RIVER DIVISION

1963

ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER

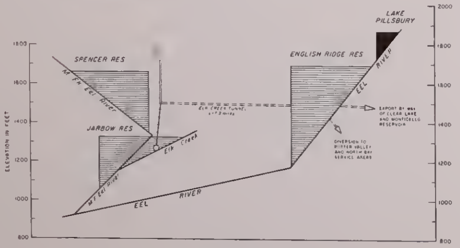
PLAN A

RECONNAISSANCE SUMMARY OF COSTS FOR THE DEVELOPMENT AND PUMPED DIVERSION TO ENGLISH RIDGE RESERVOIR OF NEW FIRM EXPORTABLE WATER YIELD DERIVED FROM SURPLUS FLOWS OF THE MIDDLE FORK EEL RIVER



PLAN

SCALE OF MILES



PROFILE

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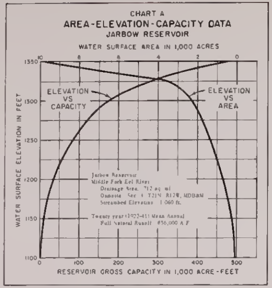

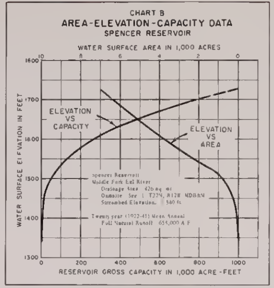

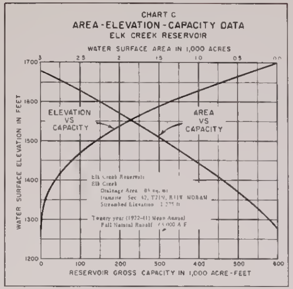

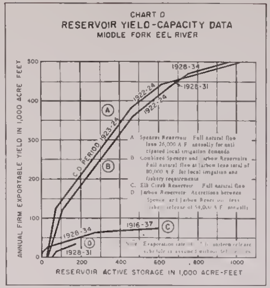

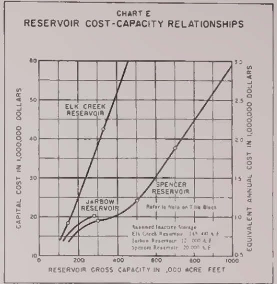

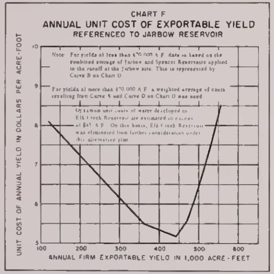

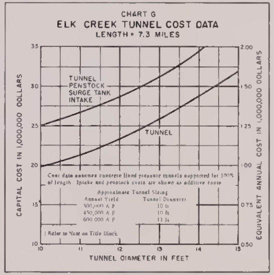

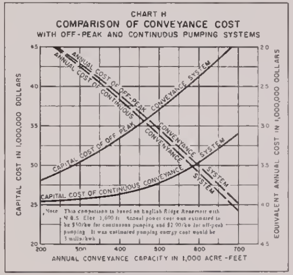

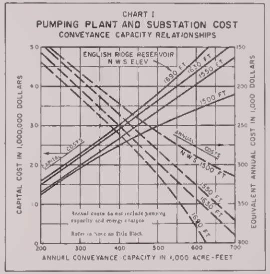

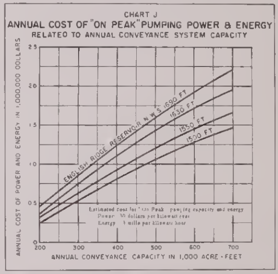

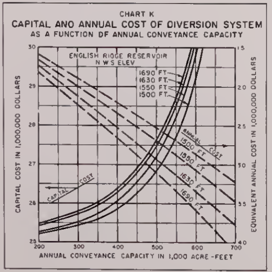

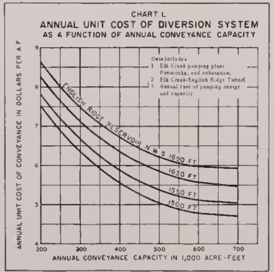

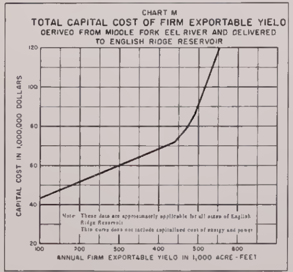

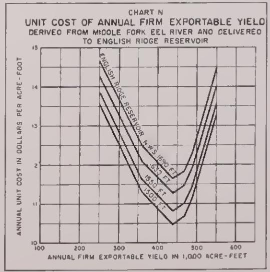

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NORTH COASTAL AREA INVESTIGATION

UPPER EEL RIVER DIVISION

1963

ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER

PLAN A

RECONNAISSANCE SUMMARY OF COSTS FOR THE DEVELOPMENT AND PUMPED DIVERSION TO ENGLISH RIDGE RESERVOIR OF NEW FIRM EXPORTABLE WATER YIELD DERIVED FROM SURPLUS FLOWS OF THE MIDDLE FORK EEL RIVER

PLATE 16

ALTERNATE PLANS FOR DEVELOPMENT OF THE MIDDLE FORK OF THE EEL RIVER - PLAN B

Water Developed in Dos Rios and Spencer Reservoirs Diverted to English Ridge Reservoir

The purpose of this plate is to summarize costs and other pertinent data related to diversion of Middle Fork Eel River flows to English Ridge Reservoir. A basic assumption in the development of this plate was that Round Valley would be protected from inundation.

Four possible reservoirs were considered in the plan of a pumped diversion from the Middle Fork Eel to English Ridge Reservoir. They are: Spencer, Etsel, Jarbow, and Dos Rios. Elk Creek Reservoir was eliminated from consideration by earlier work depicted on Plate 15. Jarbow and Dos Rios Reservoirs can either be built as single units which would have large storage and appurtenant works (Mill Creek Dam, Franciscan Dam, and Round Valley Drainage Tunnel) to protect the valley, or they could be built as relatively small storage units which would be combined with the alternative Spencer or Etsel Reservoirs upstream.

The plan presented on this plate is based on "on-peak" or continuous pumping, which is equivalent to delivery of water to English Ridge Reservoir on a uniform monthly schedule. For purposes of this analysis, English Ridge Reservoir was assumed to be constructed to a capacity of 1,800,000 acre-feet, normal water surface elevation 1,695 feet. Data on Plate 15 can be used as a basis for estimating cost of diversion to various capacities of English Ridge Reservoir.

Plate 17 of this series presents a comparative analysis of a gravity diversion and a pumped diversion from the Middle Fork to English Ridge Reservoir, under the assumption that Round Valley would be inundated by a large Dos Rios Reservoir.

CHART A:

This chart presents area-elevation-capacity data for Spencer Reservoir. These relationships were developed from the Department of Water Resources' Upper Etsel Reservoir map dated January 7, 1959. The scale of this map is 1-inch = 400 feet, and the contour interval is 20 feet.

CHART B:

This chart presents area-elevation-capacity data for Etsel Reservoir. These relationships were developed from the Department of Water Resources' Dos Rios Reservoir map dated November 1959, and the Etsel Reservoir map dated August 1959. The scale of these maps is 1-inch = 400 feet, and the contour interval is 20 feet.

CHART C:

This chart presents area-elevation-capacity data for a Jarbow Reservoir which would not inundate Round Valley. The discontinuity shown on the chart is based on the assumption that for reservoir levels of elevation 1,325 and below, no Mill Creek Dam would be built. The insertion of Mill Creek Dam in order to prevent inundation of Round Valley at reservoir levels in excess of elevation 1,325, causes a loss of reservoir storage below elevation 1,325 which results in the delineated discontinuity. Most of these data were developed from the Department of Water Resources' Dos Rios Reservoir map dated November 1959, and the Etsel Reservoir map dated August 1959. A small portion of the area, particularly that between elevations 1,300 and 1,325 in Round Valley, was derived from 1:62,500 scale USGS quadrangles, with a contour interval of 50 feet.

CHART D:

This chart presents area-elevation-capacity data for a Dos Rios Reservoir which would not inundate Round Valley at reservoir levels in excess of elevation 1,325. The reasons for the existence of a discontinuity in these data and the maps used are the same as those given in the description of Chart C.

CHART E:

This chart presents estimated capital and annual cost-storage capacity relationships for Spencer and Etsel Reservoirs. Cost estimates for Spencer Reservoir are available at gross storages of 300,000, 500,000, 580,000, 700,000, and 900,000 acre-feet. Cost estimates for Etsel Reservoirs are available at gross storages of 880,000, 1,150,000, and 1,410,000 acre-feet. Estimates for capital costs include allowances of 15 percent for engineering and project administration charges and 15 percent for contingencies. Estimates for equivalent annual costs include allowances for project operation, maintenance, replacement, and capital recovery at 4 percent interest for a 50-year period.

CHART F:

This chart presents estimated capital and annual cost-storage capacity relationships for Jarbow and Dos Rios Reservoirs. Cost Estimates for Jarbow Reservoir are available at gross storages of 200,000, 285,000 1/, 750,000, 1,760,000, and 3,100,000 acre-feet. Cost estimates for Dos Rios Reservoir are available at gross storages of 430,000 1/, 595,000 1/, 500,000, 1,900,000, and 3,430,000 acre-feet. The discontinuities shown are the result of the previously discussed discontinuity in storage-capacity elevation data, and a concurrent discontinuity in costs which result from the abrupt addition of the cost of Mill Creek Dam and Round Valley Drainage Tunnel at normal water surface elevation 1,325. Capital and annual costs include the allowances discussed under the heading "Chart E".

CHART G:

This chart delineates the relationship between unit cost of storage and active storage for the four reservoirs under consideration. Inactive storages are as follows:

Reservoir	Inactive Storage (acre-feet)
Spencer	20,000
Etsel	20,000
Jarbow	120,000
Dos Rios	340,000

The 20,000 acre-feet of inactive storage at Spencer and Etsel Reservoirs was based on a reconnaissance estimate of storage required for sediment. The inactive storage for Jarbow and Dos Rios Reservoirs corresponds to an elevation of 1,275 feet. This minimum pool elevation was set to establish a reasonable location for the pumping plant.

The relatively higher unit costs of storage at Etsel and Jarbow Reservoirs indicate elimination of these reservoirs from further consideration within this context, since the yield-storage relationships for these reservoirs are assumed to be identical to those for Spencer and Dos Rios, respectively.

1/ Without Mill Creek Dam

CHART H:

This chart presents firm water yield-storage capacity data for Spencer Reservoir, the accretion below Spencer Reservoir to Dos Rios Reservoir, and a combination of the two reservoirs. Curve A represents the storage-yield relationship for a combination of Spencer and Dos Rios Reservoir. Inflows were developed by a combination of correlation and area-precipitation techniques. For this analysis, natural flows were considered to be depleted by a release of 54,000 acre-feet for fisheries and 26,000 acre-feet for consumptive use in Round Valley. Curve B delineates the storage-yield relationship for Spencer Reservoir. Inflows were developed from correlation with existing record of natural flows. The estimated 26,000 acre-feet of annual consumptive use in Round Valley, which was distributed on an irrigation schedule, was then subtracted from these natural flows. Curve C is based on the same data. It is, however, based on a power demand schedule corresponding to generation of 2,630 kilowatt hours per kilowatt per year. All other curves are based on a uniform demand schedule without deficiencies. Curve D is based on the accretions between Spencer and Dos Rios Reservoirs less an annual release of 54,000 acre-feet for fisheries.

The storage-yield relationships were corrected for evaporation by use of an empirical expression:

$$C = E \times \left[0.60\ (MA - LA) + LA\right]$$

where,

C = Annual evaporation correction during critical period of reservoir operation.

E = Annual evaporation rate (assumed to be 2.5 feet)

MA = Area of maximum pool

LA = Area of minimum pool

CHART I:

This chart presents data on the annual unit cost per acre-foot of yield as related to the annual quantity of yield developed. Curve A is based on operation of a powerplant at Spencer Dam at a 50 percent capacity factor which approximates a uniform schedule on a monthly basis. Minimum power pool was established so that minimum head was 65 percent of design head, or about 50 percent of maximum head. Reservoir costs and power costs and revenues are included. Curve B delineates the unit cost of yield if no powerplant is built. Curve C gives the unit cost of yield if a powerplant at Spencer is operated on a 30 percent load factor. Values of $26.30 per kilowatt-year and $.0033 per kilowatt hour were used for power and energy developed on 50 percent capacity factor, in order to evaluate the transmission cost savings possible from the coordination of this development with the Elk Creek Pumping Plant. These savings are not possible when a 30 percent capacity factor is considered, because more capacity would be generated at Spencer than is required at the pumping plant, and consequently, the transmission liability would have to be included.

CHART J:

This chart presents data for a powerplant at Spencer Dam operated on a 50 percent load factor. Costs were taken from data prepared by the North Coastal Area Investigations Unit. Revenue was based on rates of $26.30 per kilowatt per year and $.0033 per kilowatt hour. The validity of these rates is discussed above.

CHART K:

This chart presents the annual unit cost of yield referenced to Dos Rios Reservoir. If Dos Rios Reservoir is limited to a normal water surface elevation of 1,325, which is the assumption on this chart, the yield potential is limited to about 225,000 acre-feet annually. To develop more yield, Spencer Reservoir must be added. The effect of an optimum Spencer development (see Chart J) and a Dos Rios Reservoir, which is limited in size, is shown.

CHART L:

This chart presents storage-yield data which are assumed to be applicable to both Dos Rios and Jarbow Reservoirs. Natural flows were developed by combination of area-precipitation data and correlation techniques. Since Round Valley would be provided with a drainage outlet, 85 percent of the flows of Mill Creek would not accrue to the reservoir. However, they would be used, whenever available, to meet the annual release of 54,000 acre-feet required for fisheries. The balance of the fish requirements and the estimated annual consumption of 26,000 acre-feet of irrigation water for Round Valley would be met from natural inflows remaining after the Mill Creek subtraction. The storage-yield data were corrected for evaporation losses as described for Chart H.

CHART M:

This chart delineates the relationship between the annual unit cost of yield and the annual yield for Dos Rios Reservoir. In this context, Dos Rios Reservoir works include Dos Rios Dam, Mill Creek Dam, Franciscan Dam, and the Round Valley Drainage Tunnel. These are the works necessary to protect Round Valley.

CHART N:

The following table indicates the component features and other cost data or sources of data for the diversion system:

Feature	Cost Data
Tunnel	Curve by Northern Branch, Design Unit
Penstock and intake	Approximated by ratio of tunnel costs
Pumping plant	From data developed by Mr. L. A. Brown for the North Coastal Area Investigation
Substation	$15 per kilowatt
Power	$29.30 per kilowatt-year
Energy	$.0033 per kilowatt hour

Allowances for cost of engineering, contingencies, and administration were made, where applicable. It was assumed that the diversion would be to an English Ridge Reservoir having a normal water surface elevation of approximately 1,690 feet and an average water surface elevation approximating 1,635 feet.

CHART O:

This chart delineates the annual cost per acre-foot of conveying water to English Ridge Reservoir from both of Middle Fork Eel River development systems herein considered. These data were obtained by division of the annual cost data of Chart N by the appropriate annual yield.

CHART P:

This chart presents the summation of capital and annual costs for diversion and reservoir development for the yield range under consideration.

CHART Q:

This chart shows the unit costs of annual exportable yield delivered to English Ridge Reservoir. The optimum unit cost appears to be slightly in excess of $11 for both plans. The yield of the plan combining Spencer and a limited Dos Rios Reservoir would be about 470,000 acre-feet, while the yield of a large Dos Rios Reservoir at minimum unit cost would be about 665,000 acre-feet.

CHART E
ESERVOIR COST-CAPACITY RELATIONSHIPS
SPENCER AND ETSEL RESERVOIRS

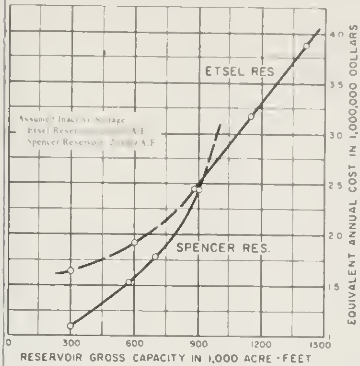


CHART F
RESERVOIR COST-CAPACITY RELATIONSHIPS
JARBOW AND DOS RIOS RESERVOIRS

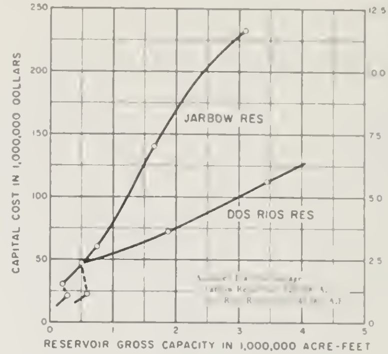


CHART K
NUAL UNIT COST OF YIELD FROM SPENCER
AND DOS RIOS RESERVOIRS
REFERENCED TO DOS RIOS RESERVOIR

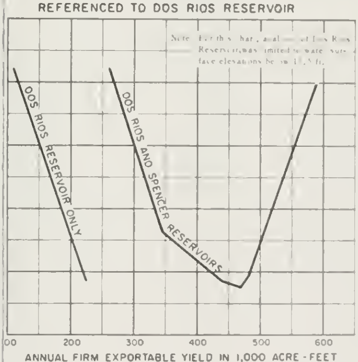


CHART L
STORAGE-YIELD DATA
JARBOW OR DOS RIOS RESERVOIR

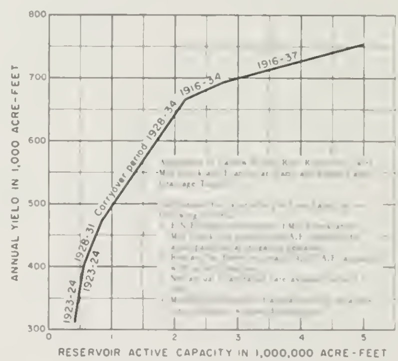
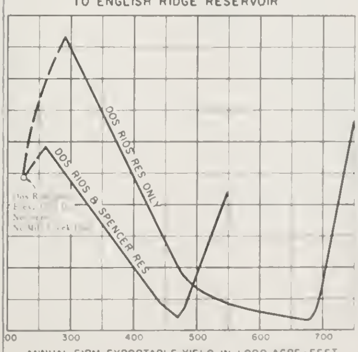


CHART Q
NUAL UNIT COST OF FIRM EXPORTABLE YIELD
RIVED FROM MIDDLE FORK EEL RIVER AND DELIVERED
TO ENGLISH RIDGE RESERVOIR



Notes:

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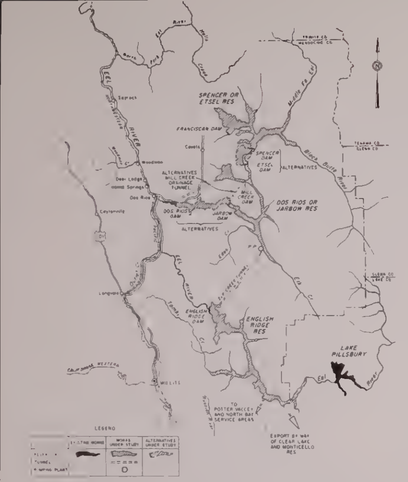
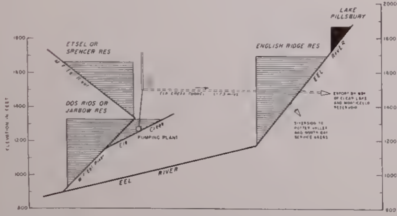
ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER
PLAN B

RECONNAISSANCE SUMMARY OF COST FOR THE DEVELOPMENT AND PUMPED DIVERSION TO ENGLISH RIDGE RESERVOIR OF NEW FIRM EXPORTABLE WATER YIELD DERIVED FROM SURPLUS FLOWS OF THE MIDDLE FORK EEL RIVER





PROFILE

NO HORIZONTAL SCALE

CHART A
AREA-ELEVATION-CAPACITY DATA
SPENCER RESERVOIR

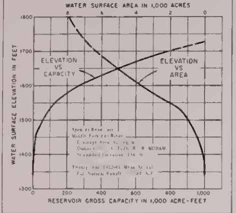


CHART B
AREA-ELEVATION-CAPACITY DATA
ETSEL RESERVOIR

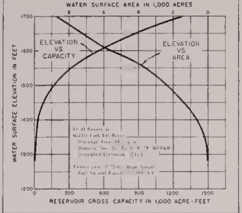


CHART C
AREA-ELEVATION-CAPACITY DATA
DOS RIOS RESERVOIR

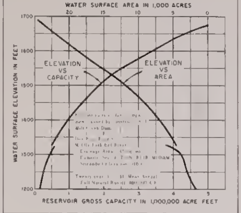


CHART D
AREA-ELEVATION-CAPACITY DATA
JARBOW RESERVOIR

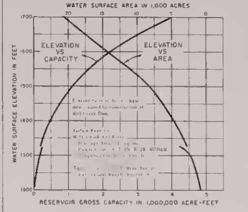


CHART E
RESERVOIR COST-CAPACITY RELATIONSHIPS
SPENCER AND ETSEL RESERVOIRS

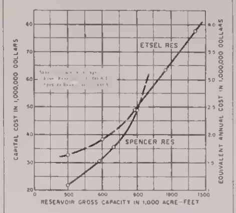


CHART F
RESERVOIR COST-CAPACITY RELATIONSHIPS
JARBOW AND DOS RIOS RESERVOIRS

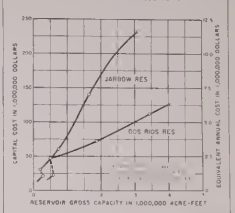


CHART G
UNIT CAPITAL COST OF ACTIVE STORAGE

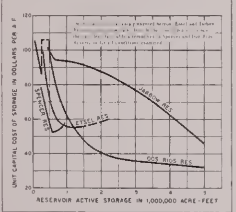


CHART H
STORAGE-YIELD DATA
MIDDLE FORK EEL RIVER

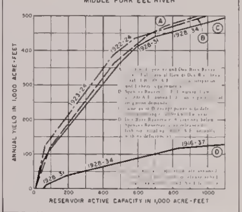


CHART I
ANNUAL UNIT COST OF YIELD
DEVELOPED BY SPENCER RESERVOIR

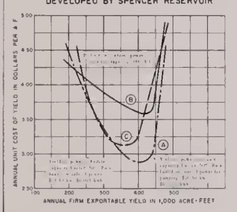


CHART J
SPENCER POWER PLANT

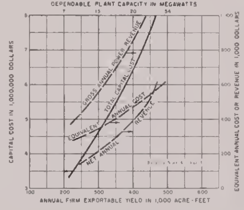


CHART K
ANNUAL UNIT COST OF YIELD FROM SPENCER AND DOS RIOS RESERVOIRS
REFERENCED TO DOS RIOS RESERVOIR

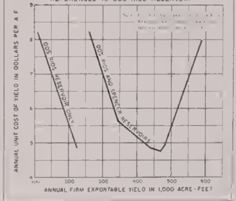


CHART L
STORAGE-YIELD DATA
JARBOW OR DOS RIOS RESERVOIR

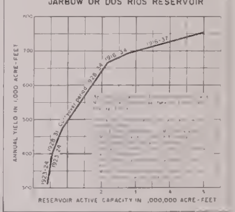


CHART M
ANNUAL UNIT COST OF YIELD
DEVELOPED BY DOS RIOS RESERVOIR

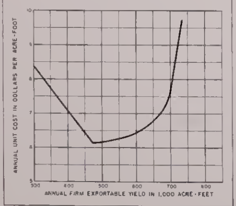


CHART N
CAPITAL AND ANNUAL COSTS OF DIVERSION
SYSTEM TO ENGLISH RIDGE RESERVOIR

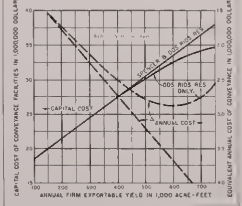


CHART O
ANNUAL UNIT COST OF DIVERSION SYSTEM
TO ENGLISH RIDGE RESERVOIR

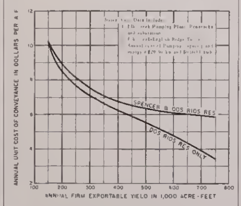


CHART P
TOTAL COST OF FIRM EXPORTABLE YIELD
DERIVED FROM MIDDLE FORK EEL RIVER AND DELIVERED
TO ENGLISH RIDGE RESERVOIR

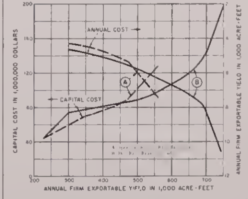
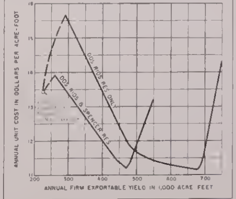


CHART Q
ANNUAL UNIT COST OF FIRM EXPORTABLE YIELD
DERIVED FROM MIDDLE FORK EEL RIVER AND DELIVERED
TO ENGLISH RIDGE RESERVOIR



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ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER
PLAN B

RECONNAISSANCE SUMMARY OF COST FOR THE DEVELOPMENT AND PUMPED DIVERSION TO ENGLISH RIDGE RESERVOIR OF NEW FIRM EXPORTABLE WATER YIELD DERIVED FROM SURPLUS FLOWS OF THE MIDDLE FORK EEL RIVER

PLATE 17

ALTERNATIVE PLANS FOR DEVELOPMENT OF THE MIDDLE FORK OF THE EEL RIVER - PLAN C

Water Developed in Dos Rios Reservoir Diverted to English Ridge Reservoir by Gravity and by Pumping

The purpose of this plate is to summarize costs and other pertinent data for two possible plans of developing the Middle Fork Eel River by way of English Ridge Reservoir. The data presented on the plate are based on the assumption that Round Valley would be inundated. We do not presently contemplate the future inundation of Round Valley. However, to permit an objective comparison of alternatives, the benefits and detriments of a large reservoir which would flood the valley must be evaluated.

Plates 15 and 16 of this series present analyses of plans for developing the Middle Fork by way of English Ridge Reservoir with Round Valley protected. Plate 15 presents Plan A, which is an analysis of a system involving Spencer, Jarbow, and Elk Creek Reservoirs with pumped diversion to English Ridge. Plate 16 presents Plan B, which is an analysis of a system with alternative upstream Middle Fork developments of Spencer or Etsel and pumped diversion from either Jarbow or Dos Rios Reservoirs.

This plate summarizes Plan C, which is an analysis of the following alternative methods for diversion to English Ridge: (1) gravity diversion from a large Dos Rios Reservoir, or (2) pumped diversion from a smaller Dos Rios Reservoir. The analysis of the pumped diversion plan is based on "continuous" or "on-peak" pumping.

The analysis of alternative diversion methods presented in this plate was originally made using Jarbow Reservoir rather than Dos Rios Reservoir. That analysis was completed in July 1962, and was summarized on then Plate 16. Data available at that time indicated the Dos Rios Reservoir would cost about 10 percent more than Jarbow Reservoir. However, in December 1962, the Northern Branch Design Unit completed their preliminary cost estimates for the two projects which indicated that Dos Rios is a more favorable development than Jarbow. The analysis has therefore been revised to include Dos Rios Reservoir and is being summarized as Plate 17.

CHART A:

This chart presents area-elevation-capacity data for Dos Rios Reservoir. These relationships, below elevation about 1,500 feet, were developed from topographic maps compiled by Messrs. Hammond, Jensen, and Wallen, to a scale of one inch equals 1,000 feet, contour interval of 20 feet, dated February 1950. U. S. Geological Survey quadrangle maps, scale 1:62,500, with contour intervals of 50 and 100 feet, were used for the portion above elevation 1,500 feet, including Round Valley.

CHART B:

This chart presents reservoir yield-storage capacity data for Dos Rios Reservoir. Runoff data for Dos Rios damsite were revised in May 1962. The revised data were used in this study and are included in the office report, "Estimates of Full Natural Flows in the Eel River Basin".

Releases for the purpose of fisheries enhancement, amounting to 54,000 acre-feet per year, were provided on the following schedule:

Month	Release in 1,000 A.F.	Month	Release in 1,000 A.F.
Oct.	6.0	Apr.	4.2
Nov.	6.0	May	4.2
Dec.	6.0	June	4.2
Jan.	6.0	July	2.4
Feb.	6.0	Aug.	2.4
Mar.	4.2	Sept.	2.4

The storage-yield relationships were corrected for evaporation by use of an empirical expression:

$$C = E \times \left[0.60\ (MA - LA) + LA\right]$$

Where,

C = Annual evaporation correction during critical period of reservoir operation.

E = Annual evaporation rate (assumed to be 2.5 feet).

MA = Area of maximum pool.

LA = Area of minimum pool.

The storage-yield relationships were plotted with gross reservoir capacity as abscissa, rather than active capacity, to graphically illustrate the substantial difference in inactive storage requirement between the alternative diversion plans.

CHART C:

This chart presents reservoir cost-storage capacity data for Dos Rios Reservoir. The curve was based on designs and cost estimates of three dams. The corresponding normal water surface elevations and reservoir capacities are:

N.W.S. Elev. in Feet	Capacity in Acre-Feet	Capital Cost in $1,000,000
1,300	450,000	$ 18.2
1,500	4,000,000	69.2
1,600	7,500,000	93.6

These cost estimates reflect the Round Valley property estimates made in March 1962 by the Acquisition Section, and include adjustments made on January 1963 for projected increase of property value in Round Valley to the year 1980.

CHART D:

This chart presents the unit capital cost of storage in Dos Rios Reservoir. The curve is plotted against gross reservoir capacity to be consistent with the other charts on this plate.

CHART E:

This chart presents a comparison of the annual unit cost of firm exportable yield in Dos Rios Reservoir for the gravity and for the pumping plan.

The cost handicap imposed by the enormous amount; i.e., 4,600,000 acre-feet of inactive storage in the gravity plan, carries completely through the analysis and is reflected in the final unit cost curves. A dam about 620 feet high would be required to impound this inactive storage alone. A pertinent consideration is that it may take five or more years to fill the inactive storage pool. Thus, the difference between the pumping and gravity plan would be even greater if the effect of time-of-filling was included in the analysis.

CHART F:

This chart presents cost data for the 7.3 mile long Elk Creek Tunnel. Details of the design and cost estimates are included in the report, "English Ridge-Jarbow-Upper Mina Connecting Tunnel". The cost of the tunnel for the gravity plan is directly from the report. The cost of the tunnel for the pumping plan includes the cost of an intake, penstocks, gates, and appurtenances.

The sizing of the tunnel for the gravity plan is based on the uniform annual yield from Dos Rios Reservoir and an assumed minimum head differential of 20 feet; thus the setting of Dos Rios Reservoir minimum pool elevation at 1,520 feet and English Ridge Reservoir minimum pool elevation at 1,500 feet. The latter was set to provide gravity flow through Garrett Tunnel, invert elevation 1,500 feet. The sizing of the tunnel for the pumping plan was based on minimum cost from trial combinations of tunnel sizes and pumping installations.

A tunnel 10 feet in diameter was set as a reasonable minimum size which would be constructed for this distance of 7.3 miles.

CHART G:

This chart presents capital and annual cost of pumping plants and substations as a function of exportable yield.

The pumping plants were sized on the basis of "on peak" or "continuous pumping" of exportable yield. The static heads on the plants were based on the difference between the average water surface elevations in Dos Rios and English Ridge Reservoirs. Inasmuch as monthly operations were not run, the estimates of pumping heads are quite approximate. However, pumping plant costs amount to less than 10 percent of the total capital cost of the pumping plan, so changes in pumping plant heads will not alter the final answer appreciably.

The capital cost of the pumping plants was computed from U. S. Bureau of Reclamation data (Appendix A) on hydroelectric plants, using the following expression:

$$C = \frac{K\ (MW)^{.986}}{(H)^{.493}}$$

Where, C = Capital cost in one million dollars

K = Constant (2.45), for 2-unit installations

MW = Installed capacity in megawatts

H = Dynamic head, in feet

Costs from the expression agree very closely with Bulletin No. 78 data on pumping plant costs.

Capital costs of substations, annual costs of operation, maintenance, and general expense for pumping plants and substations were taken from curves based on Federal Power Commission data on hydroelectric installations.

The four curves each, for capital and annual costs, correspond to costs of installations required to pump to various sizes of English Ridge Reservoir. The selection of these particular sizes correspond to break-points in the English Ridge Reservoir storage-yield curve. The four sizes of English Ridge Reservoir, corresponding to the normal water surface elevation shown on the plate, which were used throughout this analysis, are shown below:

N.W.S. Elev.	Storage Capacity
1,500 feet	410,000
1,550 feet	640,000
1,630 feet	1,200,000
1,690 feet	1,800,000

A comparison between "off-peak" and "continuous pumping" is presented as Chart G on Plate 15.

CHART H:

This chart shows the total capital and annual costs of conveyance facilities for the pumping plan as a function of conveyance capacity. Cost of conveyance facilities for the gravity plan is simply the cost of Elk Creek Tunnel, shown on Chart F.

The total capital cost for the pumping plan is composed of the costs of Elk Creek Tunnel, Chart F, and the pumping plant, and the substation, Chart G. The annual costs, in addition to those of the tunnel, pumping plant, and the substation, include costs of power and energy at $29.30 per kilowatt of dependable capacity and $.0033 per kilowatt-hour.

CHART I:

This chart presents the estimated annual unit cost of conveying water to various sizes of English Ridge Reservoir. As might be expected, the greater the yield, the less the unit cost of conveyance.

The curve for the gravity plan is applicable for all sizes of English Ridge Reservoir with normal water surface elevations less than

1,650. This limitation is imposed by the maximum practical size of Dos Rios Reservoir for which data are available.

CHART J:

This chart shows a comparison of the total capital cost of exportable yield delivered to English Ridge Reservoir, for the gravity and pumping plans.

For the optimum gravity plan, the capital cost is about $137 million, divided on about an 80 percent-20 percent split for reservoir and tunnel cost.

For the optimum pumping plan to the largest size English Ridge Reservoir, the capital cost is about $90 million, broken down as follows: Dos Rios Dam and Reservoir, 65 percent; pumping plant, 10 percent; Elk Creek Tunnel, 25 percent.

The reason that there is only one curve shown for all sizes of English Ridge Reservoir is that the dam, reservoir, and tunnel costs comprise about 90 percent of the total cost, and these two items are nearly the same for all sizes. The major change for the various sizes of English Ridge Reservoir is in the pumping installation, and since it comprises only about 10 percent of the total cost, there is actually very little difference in the total costs. When plotted to a scale of 1-inch equals $25 million, the difference is negligible.

CHART K:

This chart shows the unit cost of annual exportable yield delivered to various sizes of English Ridge Reservoir.

The results indicate that pumping from the Middle Fork is probably more favorable than a gravity diversion, and that the size of English Ridge does not have appreciable influence on the cost.

LATIONSHIP

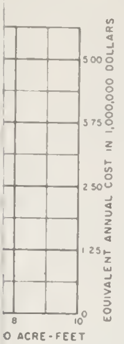
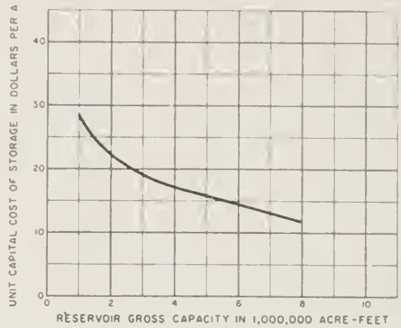


CHART D

UNIT CAPITAL COST OF GROSS STORAGE CAPACITY

DOS RIOS RESERVOIR



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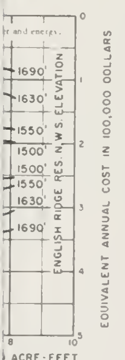
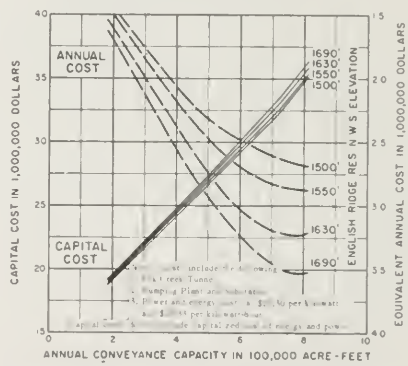


CHART H

TOTAL CAPITAL AND ANNUAL COST

OF PUMPING DIVERSION SYSTEM

AS A FUNCTION OF ANNUAL CONVEYANCE CAPACITY



RTABLE YIELD
AND DELIVERED
VOIR

Notes

All estimates for capital costs of tunnels, pumping plants and reservoirs include allowances of 15% for contingencies and 5% for engineering and project administration charges. Estimates for equivalent annual costs include allowances for project operation, maintenance and replacement for a 50 year capital recovery period with annual interest rate of 4.0%.

The analysis presented on this plate is based on "On-Peak" or continuous pumping [illegible] English Ridge Reservoir.

Alternative plans for development of the Middle Fork Eel River are summarized on the following plates:

PLATE NO.	PLAN	RESERVOIR	DIVERSION
15	A	Spencer, Eel Creek, Jarbow excluding Round Valley	Pumped
16	B	Spencer or Etsel, Jarbow or Dos Rios, excluding Round Valley	Pumped
17	C	Dos Rios including Round Valley	Pumped or Gravity

STATE OF CALIFORNIA

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NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION

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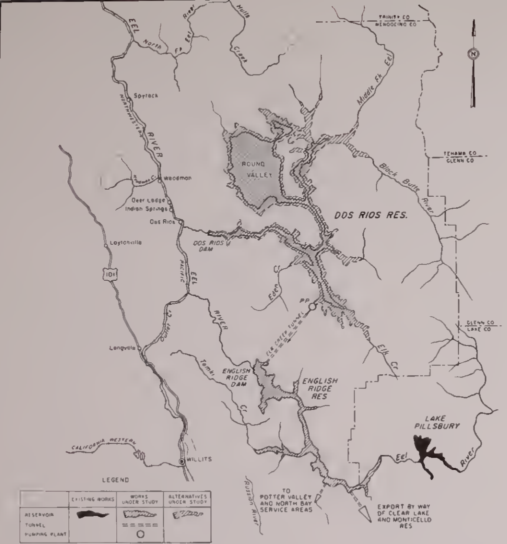
ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER

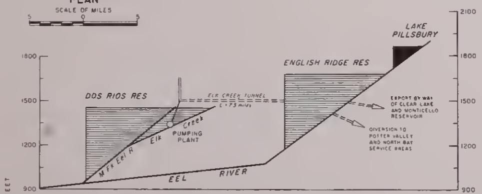
PLAN C

RECONNAISSANCE COMPARISON OF PUMPED VERSUS GRAVITY DIVERSION TO ENGLISH RIDGE RESERVOIR OF FIRM WATER YIELD DERIVED FROM MIDDLE FORK EEL RIVER



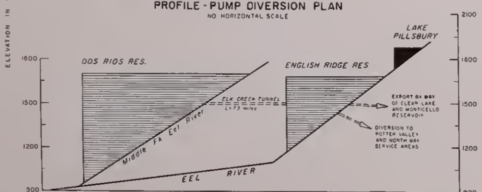
PLAN

SCALE OF MILES



PROFILE - PUMP DIVERSION PLAN

NO HORIZONTAL SCALE



PROFILE - GRAVITY DIVERSION PLAN

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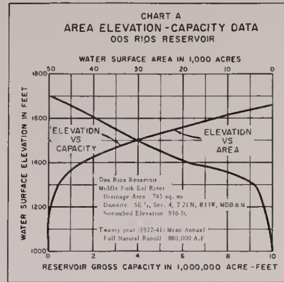

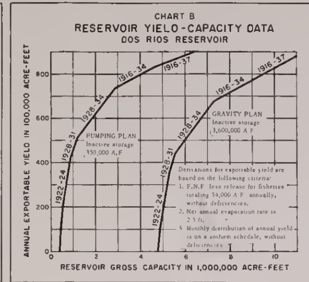

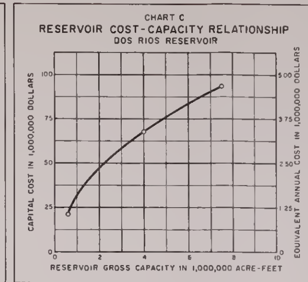

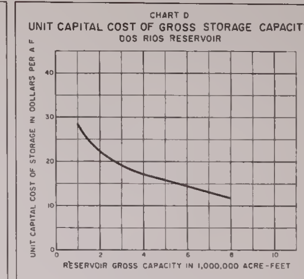

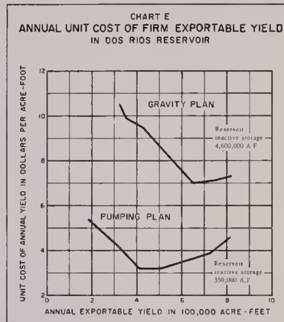

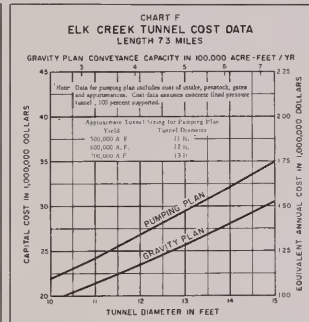

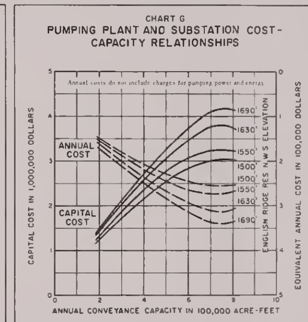

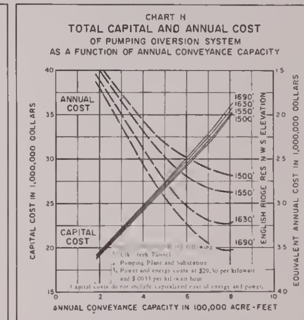

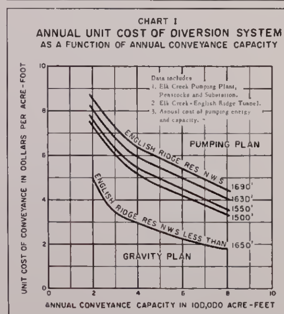

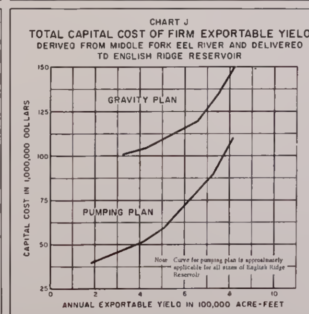

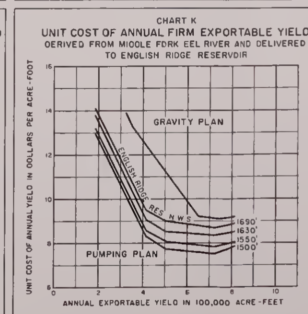

Notes

1. All estimates for capital costs of tunnels, pumping plants and reservoirs include allowances of 15% for contingencies and 15% for engineering and project administration charges. Estimates for equivalent annual costs include allowances for project operation, maintenance and replacement for a 50 year capital recovery period with annual interest rate of 4.0%.

2. The analysis presented on this plate is based on "On-Peak" or continuous pumping into English Ridge Reservoir.

3. Alternative plans for development of the Middle Fork Eel River are summarized on the following plates

PLATE NO	PLAN	RESERVOIR	DIVERSION
15	A	Spencer, Elk Creek, Jarbow excluding Round Valley	Pumped
16	B	Spencer or Etsel, Jarbow or Dos Rios, excluding Round Valley	Pumped
17	C	Dos Rios including Round Valley	Pumped or Gravity

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NORTH COASTAL AREA INVESTIGATION

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ALTERNATIVE PLANS FOR DEVELOPMENT OF MIDDLE FORK EEL RIVER PLAN C

RECONNAISSANCE COMPARISON OF PUMPED VERSUS GRAVITY DIVERSION TO ENGLISH RIDGE RESERVOIR OF FIRM WATER YIELD DERIVED FROM MIDDLE FORK EEL RIVER

PLATE 18

ALTERNATIVE PLANS FOR EEL RIVER DEVELOPMENT

Yield Development at English Ridge, or Pressley Reservoirs, or Both, With Pumped Diversions From the Middle Fork of the Eel River

Plate 18 was prepared to illustrate cost-yield relationships when a firm annual supply of water is developed in English Ridge Reservoir from runoff of the Main Stem and Middle Fork Eel Rivers by alternative projects.

Spencer and Jarbow Reservoirs would be constructed on the Middle Fork Eel, as indicated on Plate 15 of this series, with Franciscan Dam constructed on Short Creek to prevent the inundation of Round Valley. The annual exportable yield from Spencer and Jarbow Reservoirs would be pumped through the Elk Creek Tunnel into English Ridge Reservoir on a uniform schedule.

Storage would be provided on the Main Stem Eel River by English Ridge and Pressley Reservoirs or by English Ridge Reservoir only. If Pressley Reservoir is included, power facilities would be installed at the downstream toe of Pressley Dam, and the maximum water surface elevation of English Ridge Reservoir would be 1,550 feet. If English Ridge Reservoir, only, is constructed on the main Eel, then its capacity would vary with the desired yield. It was assumed in all cases in this investigation that the minimum water surface elevation of English Ridge Reservoir and the inlet elevation of Garrett Tunnel would be 1,500 feet.

Plates 6 and 6A of this series illustrate the cost of the conveyance system (including power facilities) from English Ridge Reservoir to Lake Berryessa. Lake Berryessa would provide reregulation of the project yield prior to its release to the Sacramento River Delta.

Description of Data

CHART A: Area-Capacity Data - English Ridge Reservoir

These data were determined for the damsite located in Section 6, T19N, R12W, MDB&M, with the streambed elevation at approximately 1,180 feet.

The water surface elevation vs. area data were determined by planimetering the Department of Water Resources' English Ridge Reservoir map, produced by photogrammetry, dated April 19, 1962, scale 1:4800, with contour intervals at 20 feet. The elevation vs. capacity data were computed by the average area method.

CHART B: Area-Capacity Data - Pressley Reservoir

These data were developed for the proposed reservoir which would be formed by a dam at streambed elevation 1,500 on the Main Stem Eel River, located in Section 34, T18N, R11W, MDB&M.

The water surface elevation vs. area data were determined by planimetering the USGS quadrangles: Pomo (scale 1:62,500 contour interval 100 feet) and Lake Pillsbury (scale 1:62,500 contour interval 50 feet).

CHART C: Yield-Capacity Data - English Ridge Reservoir

These data indicate the exportable yield vs. active capacity relationship of English Ridge Reservoir, based upon the following criteria:

1. The storable inflow to English Ridge Reservoir would be the present impaired spills over Van Arsdale Dam, plus the accretions between Van Arsdale and English Ridge Dams. The exportable yield would therefore be an additional annual diversion which would not cause any depletion of the yield from existing or proposed reservoirs on the Russian River which utilize the Eel River diversion at Van Arsdale.

2. The mandatory releases to maintain the Eel River fisheries would average 59,500 acre-feet per year.

3. The distribution of yield would be uniform as to both monthly and annual deliveries without deficiencies.

4. The mean net annual evaporation rate was estimated to be 2.75 feet.

CHART D: Yield-Capacity Data - Pressley Reservoir

These data indicate the annual yield vs. active capacity relationship of Pressley Reservoir based upon the following criteria:

1. The storable inflow was considered to be the full natural flow of the Eel River at Pressley damsite. The annual yield would be released through a powerplant into English Ridge Reservoir for diversion to the Russian or Sacramento Rivers.

2. The annual distribution of yield was considered to be uniform with the monthly distribution conforming to the following power schedule:

Month	KWH/KW	Percent
Oct.	200	7.605
Nov.	170	6.464
Dec.	180	6.844
Jan.	160	6.084
Feb.	140	5.323
Mar.	220	8.365
Apr.	190	7.224
May	200	7.605
June	260	9.886
July	330	12.547
Aug.	340	12.928
Sept.	240	9.125
Totals	2,630	100.000

Powerplant Capacity Factor = 30 Percent

3. The net annual evaporation rate was estimated to be three feet.

CHART E: Cost-Capacity Data - English Ridge and Pressley Reservoirs

These data are based on estimates which were prepared to preliminary standards by the Northern Branch Design Unit.

The cost estimates were prepared for earthfill dams at the English Ridge site immediately below the junction of Old Woman Creek and the Eel River. The dams were sized for reservoirs with normal water surface elevations of 1,550, 1,650, and 1,690 feet, and storage capacities of 580,000, 1,300,000, and 1,720,000 acre-feet, respectively.

The Pressley Dam and Reservoir cost estimates were computed for rockfill dams which were sized for reservoir normal water surface elevations of 1,900 and 2,000 feet, and storage capacities of 730,000 and 1,630,000 acre-feet, respectively.

Cost estimates for both reservoirs include an allowance of 15 percent of the estimated first cost for engineering and overhead and a contingency factor of 15 percent.

CHART F: Pressley Reservoir Powerplant

These data indicate the capital cost, annual cost, and annual revenue that would be attributed to power facilities of varying capacity at Pressley Dam. The estimates of capital cost were prepared by the North Coastal Area Investigations Unit and include a contingency allowance of

15 percent and an engineering and overhead allowance of 15 percent. Power revenue was considered to be salable at the site at $22 per kilowatt of dependable capacity and three mills per kilowatt hour of usable energy.

The firm yield from Pressley Reservoir as shown on Chart D would be released through the powerplant on the previously described power schedule. It was assumed that the operating range of Pressley Reservoir would be limited so that the maximum head on the powerplant would be 125 percent of the design head, and the minimum head on the powerplant would be 70 percent of the design head.

CHART G: Capital Cost-Rate Data - New Yield from Middle Fork Eel River Delivered to English Ridge Reservoir

These data are identical to the data on Chart M of Plate 15 of this series. The data indicate the capital cost when a given annual yield is developed by Spencer and Jarbow Reservoirs on the Middle Fork Eel River and is pumped through the Elk Creek Tunnel into English Ridge Reservoir. These data do not include the cost of English Ridge Reservoir.

CHART H: Annual Cost-Rate Data - New Yield from Middle Fork Eel River Delivered to English Ridge Reservoir

These data are derived from the data on Chart N of Plate 15 of this series. The data indicate the annual cost when a given annual yield is developed by Spencer and Jarbow Reservoirs on the Middle Fork Eel River and is pumped through the Elk Creek Tunnel into English Ridge Reservoir. These data do not include the cost of English Ridge Reservoir.

CHARTS I, J, AND K: Estimated Cost of Middle Fork and Main Stem Eel River Development as a Function of Firm Annual Yield

These data, which were derived from the preceding charts, indicate the estimated capital cost, net annual cost, and annual unit cost, respectively, of new yield developed by Spencer and Jarbow Reservoirs on the Middle Fork and combined with new yield from alternative projects on the Main Stem Eel River. This firm annual yield would be available in English Ridge Reservoir at the proposed Garrett Tunnel at elevation 1,500 feet.

Curve "A" indicates the cost-yield relationship of the project with English Ridge Reservoir constructed to a normal water surface elevation of 1,550 feet and Pressley Reservoir and powerplant also constructed on the Main Stem Eel River.

Curve "B" indicates the cost-yield relationship of the project with English Ridge Reservoir sized to develop the desired new yield from the Main Stem Eel River and Pressley Reservoir and powerplant are not included.

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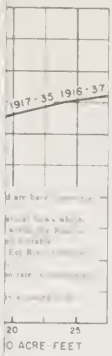
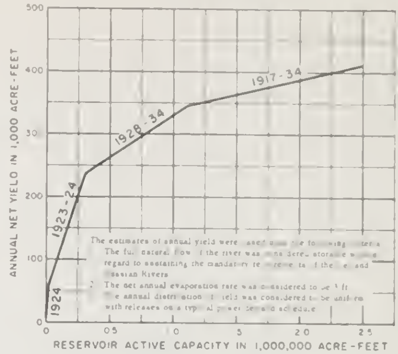


CHART D
RESERVOIR YIELD-CAPACITY DATA
PRESSLEY RESERVOIR



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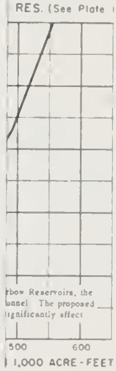
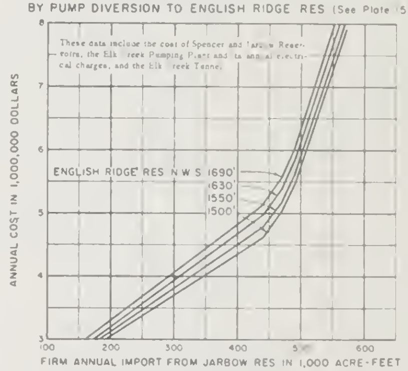


CHART H
ANNUAL COST-RATE DATA
NEW YIELD FROM MIDDLE FORK EEL RIVER, DELIVERED BY PUMP DIVERSION TO ENGLISH RIDGE RES (See Plate 15



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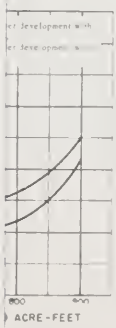

Note: These data summarize costs for the development of new exportable water supplies referenced to the point of diversion to the Sacramento Valley and/or San Francisco Bay Area. Estimated costs of the export conveyance facilities via Clear Lake and Lake Berryessa are summarized on Plate of this series.

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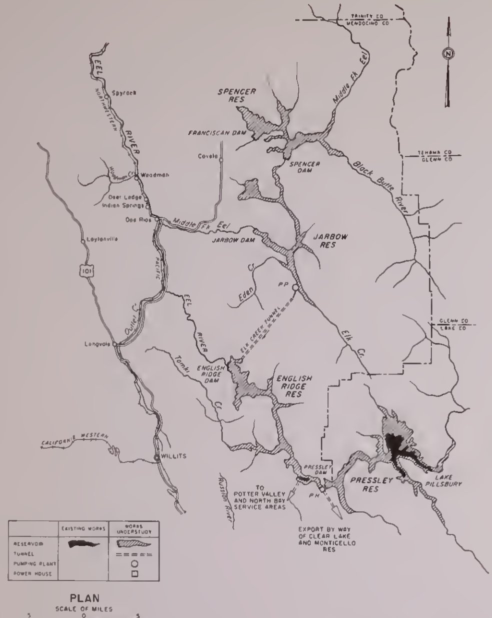
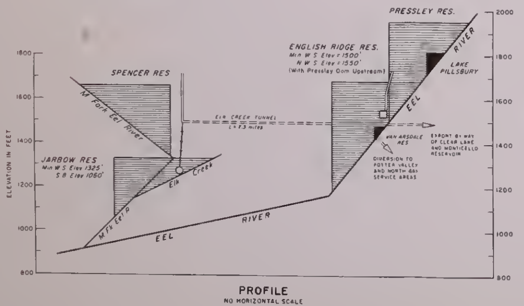
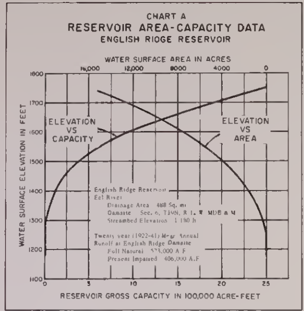
1964

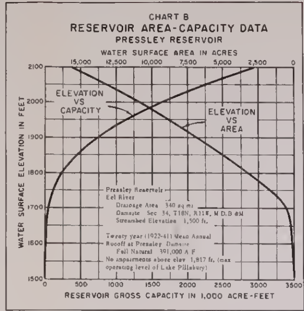
ALTERNATIVE PLANS FOR EEL RIVER DEVELOPMENT

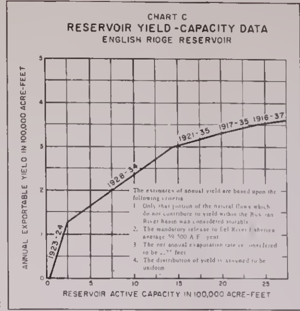
RECONNAISSANCE SUMMARY OF COSTS WHEN FIRM YIELD IS DEVELOPED BY ENGLISH RIDGE RESERVOIR AND/OR PRESSLEY RESERVOIR WITH A PUMPED DIVERSION FROM THE MIDDLE FORK EEL RIVER

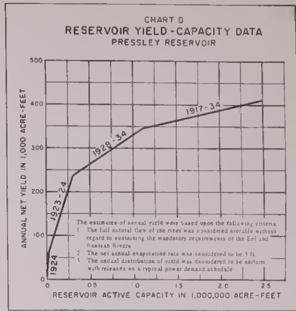


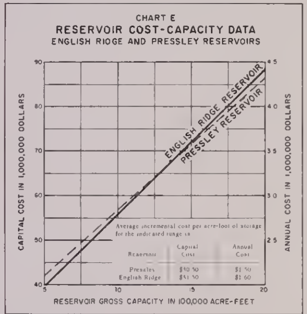


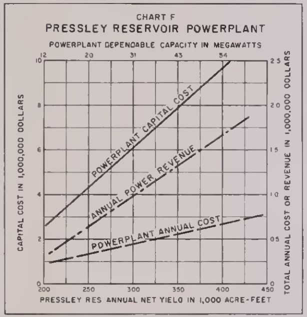


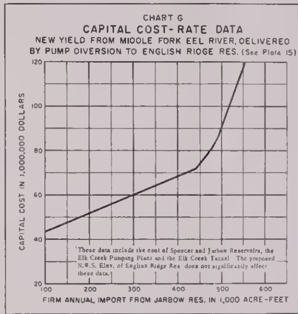


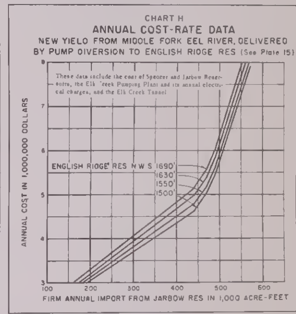


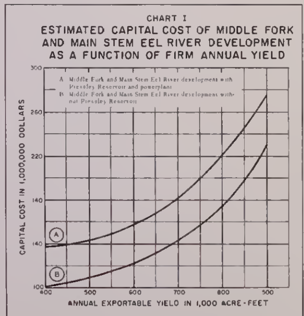


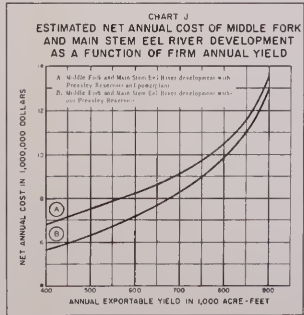


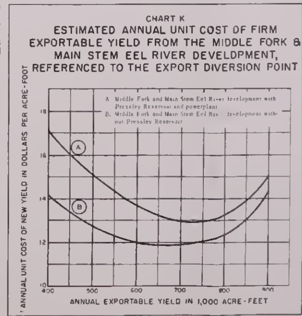












Note: These data summarize costs for the development only of new exportable water supplies referenced to the point of diversion to the Sacramento Valley and/or San Francisco North Bay Area. Estimated costs of the export conveyance facilities only via Clear Lake to Lake Berryessa are summarized on Plate 6 of this series.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
UPPER EEL RIVER DIVISION
1964

ALTERNATIVE PLANS FOR EEL RIVER DEVELOPMENT

RECONNAISSANCE SUMMARY OF COSTS WHEN FIRM YIELD IS DEVELOPED BY ENGLISH RIDGE RESERVOIR AND/OR PRESSLEY RESERVOIR WITH A PUMPED DIVERSION FROM THE MIDDLE FORK EEL RIVER

PLATE 19
LOWER EEL RIVER PROJECTS
Summary of Reconnaissance Estimates of Costs and Yields

This plate was prepared to illustrate the cost versus yield relationship of a possible reservoir development on the lower Eel River and the pumping and conveyance facilities required to deliver the water supply into either Dos Rios Reservoir on the Middle Fork Eel River or into English Ridge Reservoir on the Upper Eel River. Table 2 on page 22 shows the cost of the Grindstone Creek tunnel which could convey the water from Dos Rios Reservoir into the Glenn Reservoir Complex in the Sacramento River Basin. Plate 6A presents the cost-capacity relationship for an alternate conveyance system which could deliver a given amount of water from English Ridge Reservoir into Monticello Reservoir in the Sacramento River Basin.

In this study the water supply from the Lower Eel River would be developed by constructing Sequoia and Bell Springs Reservoirs. Dos Rios Reservoir was considered to have a normal pool elevation of 1,325 feet, and English Ridge Reservoir was considered to have a normal pool elevation of 1,695 feet.

In these reconnaissance studies consideration was not given to the recreational and flood control benefits which would be attributable to Sequoia and Bell Springs Reservoirs. In Appendix "B" (Recreation Reconnaissance of the North Coastal Area) of Bulletin No. 136, the attendance at the two possible reservoirs during the years 1990-2040 is estimated to total 155,549,000 visitors. The occurance of the great Eel River flood in December 1964 makes it apparent that reservoirs on the lower Eel River may have very significant flood control benefits which would reduce the cost of water exported from the project.

CHART A: Reservoir Area-Capacity Data - Sequoia Reservoir

These data were determined for the damsite located in Section 6, T2S, R4E, HB&M. The streambed elevation is approximately 140 feet.

The water surface elevation vs. area data were determined by planimetering USGS quadrangle maps (scale 1:62,500) having a contour interval of 100 feet. Allowance was made for the impairment which would be caused by Bell Springs Dam.

CHART B: Reservoir Yield-Capacity Data - Sequoia Reservoir

The net yield curve indicates the amount of water which could be exported from Sequoia Reservoir. The inflow was based on accretions below Bell Springs damsite.

It was considered that cold water would be released from Sequoia Reservoir to a fish hatchery which would be located at the junction of the South Fork Eel and the main Eel Rivers. Releases would also be made as necessary to provide flow below the hatchery as indicated below:

Release to Hatchery		Flow Maintained Below Hatchery	
April 1 - September 30	125 cfs	October 1 - April 30	1,060 cfs
October 1 - March 31	175 cfs	May 1 - June 30	530 cfs
		July 1 - September 30	180 cfs

It was considered in the reservoir operation study that flows of the South Fork Eel River could be utilized to provide as much of the required flow below the hatchery as possible and that a deficiency of 50 percent would be taken in fish releases during the years 1924, 1931, and 1933.

No additional yield was credited to Sequoia Reservoir for the fish releases which would no longer be required from earlier constructed upstream reservoirs.

CHART C: Reservoir Area-Capacity Data - Bell Springs Reservoir

These data were determined for the damsite located in Section 30, T24N, R14W, MDB&M. The streambed elevation is approximately 650 feet.

The water surface elevation vs. area data were determined by planimetering USGS quadrangle sheets (scale 1:62,500) having contour intervals of 50 and 100 feet. Allowance was made for the impairment caused by Dos Rios Dam. The data were revised in May 1963.

CHART D: Reservoir Yield-Capacity Data - Bell Springs Reservoir

The reservoir net yield curve indicates the amount of water which could be exported annually on a uniform schedule. The net yield is based on runoff accretions below English Ridge and Dos Rios Dams. It was considered that Sequoia Reservoir would be constructed downstream from Bell Springs Dam, and fish releases would not be made from Bell Springs Reservoir.

CHARTS E AND F: Reservoir Cost-Capacity Data - Sequoia and Bell Springs Reservoirs

The cost curves are based on a range of estimates prepared to reconnaissance standards by the Northern Branch Design Unit. The estimated costs are based on 1963 prices, and are for rockfill dams of varying heights.

The costs shown on Charts E and F are for the Sequoia and Bell Springs Dam and Reservoirs only and do not include the cost of the relocation of the Northwestern Pacific Railroad which has been estimated at $130 million.

CHART G: Cost-Capacity Data - Sequoia-Bell Springs Pumping Plant

Cost estimates of the Sequoia-Bell Springs Pumping Plant were made by the North Coastal Planning Unit. The plant was sized for off-peak pumping, and the following annual costs of electrical power were used; off-peak capacity at $0.95/KW-Yr. and off-peak energy at 2.00 mills/KWH. These values are taken from Table I of the departmental memorandum of February 11, 1964, "North Coastal Area Investigation, Value of Power and Cost of Power for Pumping", which was prepared by the Power Planning Office.

Previous operation studies of Sequoia and Bell Springs Reservoirs, sized at their optimum capacities for various yields, indicated that the average pump lift would be about 360 feet regardless of the desired amount of yield.

The basic pumping plant capital cost was increased by 25 percent to include the added cost of excavation at the plant. This would be required to allow for the fluctuation of Sequoia Reservoir and maintain a flooded suction at the pump intake.

CHART H: Cost-Capacity Data - Bell Springs-Dos Rios Pumping Plant

Cost estimates of the Bell Springs-Dos Rios Pumping Plant were made by the North Coastal Planning Unit. The electrical power costs were considered to be the same as for the Sequoia-Bell Springs Pumping Plant.

The normal water surface elevation of Dos Rios Reservoir was considered to be 1,325 feet, and the minimum water surface elevation was assumed to be 1,275 feet.

The total annual cost curve includes the annual cost of power for the pumping plant.

The basic pumping plant capital cost was increased by 25 percent to include additional cost of excavation for the plant.

CHART I: Cost-Capacity Data - Elk Creek Pumping Plant

Cost estimates of the Elk Creek Pumping Plant were made by the North Coastal Planning Unit. This pumping plant would operate on a continuous basis, and the power costs were taken from the Power Office memorandum of February 11, 1964. For unrestricted pumping, the capacity cost was considered to be $20.60/KW-Yr., and the energy cost would be 1.00 mill/KWH.

It was considered that an unlined channel would be constructed on Elk Creek to connect Dos Rios Reservoir with the Elk Creek Pumping Plant. The pumping plant discharge pipes would lead to the Elk Creek Tunnel at an elevation of 1,500 feet.

The unlined channel would be two miles in length. It would have a capital cost of $3,000,000 and an annual cost of $200,000. The pump discharge pipes would be approximately 5,000 feet in length, and were included with the pumping plant costs.

The basic pumping plant cost was increased by 50 percent to include the cost of an inlet basin and extra works associated with the intake channel.

CHART J: Cost-Capacity Data - Elk Creek Tunnel

Cost estimates of the Elk Creek Tunnel, with diameters of 15, 20, and 25 feet were prepared by the Northern Branch Design Unit. Its capacity would be such that it could convey up to 10 percent of the Lower Eel River Project's annual yield in a single month.

The allowable head loss was considered to be 20 feet.

The costs are based upon a separate Elk Creek Tunnel from that which may be included with the earlier constructed Upper Eel River Project. Economic studies indicate that separate tunnels are advisable if the Lower Eel River Project is constructed more than 16 years after the Upper Eel River Project.

A sum of $500,000 was added to the original cost estimate of the tunnel to provide for the cost of a surge tank.

CHART K: Capital Cost of Firm Exportable Yield

These data were derived from the previously described charts, and indicate the total capital cost required to develop the water yield of the lower main Eel River, and export the annual water supply to (1) Dos Rios Reservoir, and to (2) English Ridge Reservoir.

CHART L: Annual Cost of Firm Exportable Yield

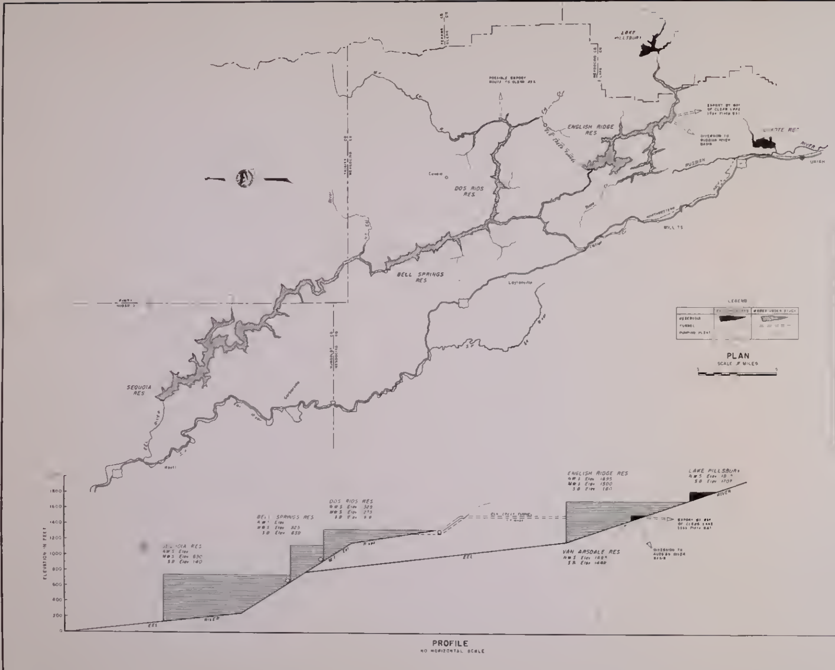
These data indicate the total annual cost, including all power costs, of the facilities required to develop and export the lower main Eel River water supply to (1) Dos Rios Reservoir, and to (2) English Ridge Reservoir.

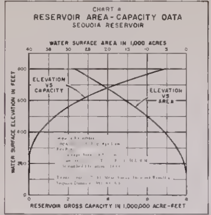
CHART M: Unit Cost of Annual Firm Yield

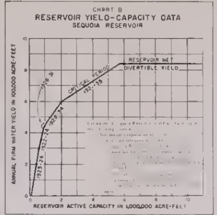
These data are derived from the previously described charts and indicate the least possible annual unit cost for the appropriate yield.

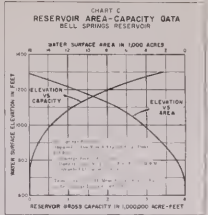
The results thus show that, if an annual yield of 1 million acre-feet per year from the lower main Eel River is to be developed and exported to an English Ridge Reservoir with a normal water surface elevation 1,695 feet, it would require a total capital cost of $480,000,000 and a unit cost of water of $28.00 for every acre-foot imported. A breakdown of the separate costs is as follows:

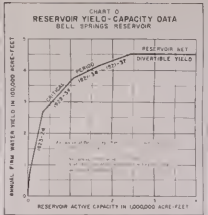
		Capital Cost
2 dams and reservoirs		$270,000,000
3 pumping plants		40,000,000
Railroad relocation		130,000,000
1 tunnel		40,000,000
	Total	$480,000,000

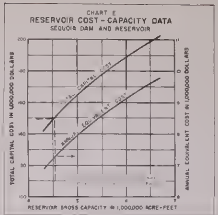


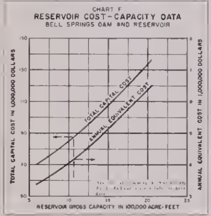


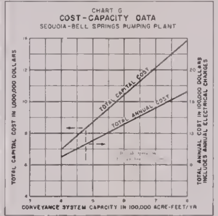


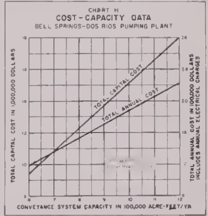


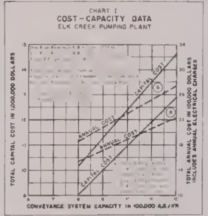


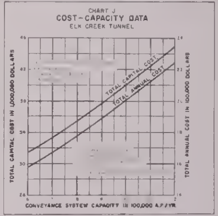


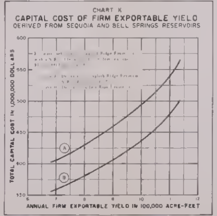


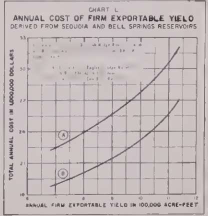


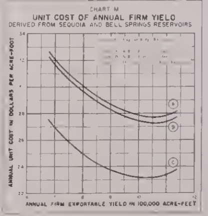












STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH

NORTH COASTAL AREA INVESTIGATION
LOWER EEL RIVER DEVELOPMENT
1964

LOWER EEL RIVER PROJECTS

SUMMARY OF RECONNAISSANCE
ESTIMATES OF COSTS AND YIELDS

PLATE 20
HUMBOLDT RESERVOIR PROJECT

The purpose of this plate is to present data on Humboldt Reservoir and four possible methods of exporting its yield to the Sacramento Valley. Each of the four methods would require a transbasin tunnel, with a length of from 12- to 60-miles. These tunnels are:

A. Clear Creek No. 3
B. Cottonwood
C. Humboldt - Iron Canyon
D. Burnt Ranch - Fiddlers

Each route has certain advantages and disadvantages which are discussed in the following descriptions of each chart.

The Humboldt Reservoir Project on the Klamath River would consist of one very large reservoir and consequently, repayment during the demand build-up period could be very difficult. One method of repayment during this period would be from power benefits derived by utilization of the great power potential at Humboldt Dam. This pump-generating plant would have all of its units reversible so that up to 70 percent of the water released for power could be pumped back into the reservoir during off-peak hours. When the water demand exceeds 70 percent of the yield, straight pumping units would be added. Ultimately, the pumping units would have a capacity of 50 percent of the pump-generating units. A power development below Humboldt Dam would probably not be considered feasible, however, if the most recently established criteria for power values had been used in the study.

Description of Charts

CHART A: Reservoir Area - Capacity Data - Humboldt Reservoir

The area was planimetered from USGS quadrangles, scale 1:62,500 and contour intervals of 50 and 100 feet. Capacity was computed by the average end area method.

CHARTS B AND C: Reservoir Yield - Capacity Data - Humboldt Reservoir

The yield of Humboldt Reservoir was computed by tabular method rather than by actual operation studies. These yields were computed for two yield schedules; Chart B is for the uniform schedule, and Chart C is for the power schedule (described in the Trinity Plates).

In each chart the yield under four different conditions is shown. Curve A applies to existing conditions. Curve B applies to conditions of ultimate local development. Curve C also applies to conditions of ultimate local development, but with Helena and Eltapom Reservoirs in operation. Curve D applies to the development for Curve C, but with Burnt Ranch Reservoir included.

CHART D: Humboldt Cost-Capacity Data - Humboldt Reservoir

The Northern Branch design unit made three reconnaissance estimates; these were for dams with a normal water surface elevation of 700, 800, and 900 feet. The solid line shown on the chart is for these estimates and all sizes in between. The dashed line is for reservoirs with normal water surface elevations of more than 900 feet or less than 700 feet, which are outside of the range estimated.

CHART E: Unit Cost of Active Storage - Humboldt Reservoir

This chart was developed from the data shown in Charts A and D. It illustrates how the unit cost of the active storage would become cheaper as the dam gets higher.

CHART F: Unit Cost-Yield Data - Humboldt Reservoir

This chart shows the unit cost of water from Humboldt Reservoir under existing and ultimate conditions. The chart also illustrates the difference between the cost of water on a uniform yield schedule and a power schedule. This curve is a product of curves B, C, and E.

CHART G: Capital Cost-Installed Capacity Data - Humboldt Power Facilities

This shows the capital cost and installed capacity for any yield between three and seven million acre-feet. For the curves with words "Initial Phase", all units are reversible. For the curves with the words "Full Pump Back", all units are not only reversible but additional straight pumping units are added in order to pump back the entire yield. Without these additional units about 30 percent of the water would be wasted.

CHART H: Net Revenue-Net Unit Revenue Data - Humboldt Power Facilities

This chart shows the net revenue and the net unit revenue for Humboldt Power Plant, with and without reversible units. Curves A and C, without reversible units, are meaningless unless the water is conveyed south by some coastal means. This curve is based on buying energy at 3.3 mills and selling at 3.0 mills, and selling dependable capacity at $22 per kilowatt per year.

CHART I: Capital Cost and Diameter vs. Yield - Export Tunnels.

This chart shows the size and cost of four possible export tunnels: Clear Creek No. 3, Cottonwood, Humboldt-Iron Canyon, and Burnt Ranch-Fiddlers.

Clear Creek Tunnel No. 3, represented by Curve A, would start at elevation 1,650 in Helena Reservoir and would discharge into Tower-house Reservoir at elevation 1,600. Its length would be about 12 miles. The sizing was determined in studies for Plate 8. The diameter is based on the available head with the water surface elevation of Helena Reservoir at 1,650 feet and that capacity required during the month of August when the average flow is about 50 percent greater than the seasonal average, due to power generation.

Cottonwood Tunnel, represented by Curve B, would start at elevation 1,500 in Helena and would discharge into Selvester Reservoir at elevation 1,500. Tunnel sizing was determined previously in the studies for a previous plate (Plate 8A), in which the same criteria were used in determining the head and design flow. The length of Cottonwood Tunnel would be 20 miles.

Humboldt-Iron Canyon Tunnel, represented by Curve C, is designed for uniform flow. Its length would be 60 miles, with an intake elevation of 600 feet and an outlet elevation of 400 feet. These elevations are fixed by the minimum pool elevation of Humboldt Reservoir and the normal pool elevation of Iron Canyon Reservoir.

Burnt Ranch-Fiddlers Tunnel, represented by Curve D, would be 35 miles long, with the intake at elevation 1,200 and the outlet elevation at 1,000. The outlet elevation is fixed by the normal water surface elevation of Fiddlers Reservoir, but the intake elevation could be modified if future studies indicate a more optimum elevation. In this study, it was presumed that Burnt Ranch Reservoir would be built only to elevation 1,200 and would have a constant pool elevation.

In using this chart, it should be remembered that tunnels A and B are designed to carry 50 percent more water for a given yield than tunnels C and D. Also tunnels A and C would deliver the yield to the Sacramento River above Iron Canyon damsite and tunnels B and D would deliver the yield to the Westside Conveyance System.

CHART J: Capital Cost and Installed Capacity vs. Yield - Trinity River Pumping Plants

This chart shows the cost and capacity of the three pumping plants associated with the Clear Creek Tunnel Route, for any yield between two and seven million acre-feet. The table at the bottom of the chart shows the design and average heads. The average head at Ironside would vary with the average water surface at Humboldt Reservoir, which would also vary with the desired yield.

These plants would operate during the off-peak hours, which means they would operate about one-half of the time.

The heads at Burnt Ranch and Helena Pumping Plants would be fixed since Helena and Burnt Ranch Reservoirs would be previously constructed as part of the Trinity Project, and Ironside Reservoir would be made only high enough to get the water to Burnt Ranch Pumping Plant.

CHART K: Annual Cost vs. Yield Data - Trinity River Pumping Plants

This chart shows the annual cost for each pumping plant, and the total annual cost of all three, if the Clear Creek Tunnel Route is used. Pumping costs would be only slightly reduced in the Cottonwood Tunnel Route. No pumping would be required in the Humboldt-Iron Canyon Tunnel Route. The Burnt Ranch-Fiddlers Tunnel Route would not require a pumping plant at Helena and would require a much smaller plant at the Burnt Ranch Dam.

CHART L: Capital Cost and Net Annual Revenue - Clear Creek Power Facilities

This chart presents the total capital cost and the total net annual revenue of the Towerhouse, Whiskeytown, Kanaka, Saeltzer and Girvan Power Plants. This chart is pertinent only to the Clear Creek Tunnel Route. The power revenue is based on the annual value of energy at 3 mills per kilowatt-hour and capacity at $22 per kilowatt per year. The Clear Creek power dams are presumed built prior to the Klamath project.

CHART M: Capital Cost and Net Annual Revenue - Clear Creek Power Facilities

This chart resembles Chart L, except that it applies to the Cottonwood Tunnel Route. The cost of Selvester Reservoir is included with the power facilities.

CHART N: Capital and Unit Cost of Water Delivered to Iron Canyon Reservoir via Clear Creek During the Demand Build-Up Period (with and without Humboldt Pump-Turbine Plant)

This chart shows how much capital is needed and what the annual unit cost of water would be, from a reservoir sized to yield 6,000,000 acre-feet annually, during the period prior to full utilization of its yield.

Initially only Humboldt Reservoir, Ironside Reservoir and pumping plants sized for the particular yield desired would be required to export water. The earlier constructed Clear Creek Tunnel No. 2 would have been sized to deliver the exportable yield from the Upper Trinity-Mad-Van Duzen Development on a power schedule with Helena Reservoir at minimum pool. The tunnel would have a capability of conveying 3,000,000 acre-feet of additional water annually if flow is continuous and if Helena Reservoir is maintained near its normal pool elevation to provide head.

It should be noted that when the full yield is utilized, the Humboldt Pump-Turbine Plant would reduce the unit cost very little. However, if the demand build-up period is very long the plant might be a worthwhile addition to the development.

CHARTS O AND P: (Summary Charts) Capital and Unit Cost of Water Delivered to Iron Canyon or Fiddlers Reservoir via all Four Conveyance Routes (without Humboldt Pump-Turbine Plant)

These charts show the total cost of developing and delivering the water to Iron Canyon or Fiddlers Reservoir by each of the four tunnel routes. For Curves A and B it was assumed Burnt Ranch and Helena Reservoirs are previously constructed. For Curve A it was also assumed that the Clear Creek power dams would be existing. For Curves B and D it was assumed that the Westside Conveyance System and Glenn Reservoir would be existing. For Curves A and C it was assumed that Iron Canyon Reservoir would be existing.

Whether or not Iron Canyon Reservoir is existing, has very little effect on these routes since it would only provide afterbay storage for Girvan Power Plant. Girvan Reservoir could provide this storage; however, Girvan Power Plant would then have to be a base plant.

Curve B, the Cottonwood Tunnel Route, and Curve D, the Burnt Ranch-Fiddlers Tunnel Route could be utilized to deliver the water to the Westside Conveyance System, which in turn would deliver it to Glenn Reservoir. Although the cost of Glenn Reservoir and the Westside Conveyance System is not included in these curves, neither are the benefits, which would include recreation, fishery enhancement, flood control and the increase in the Humboldt Reservoir Project yield through the coordination with the Delta and San Luis Reservoir.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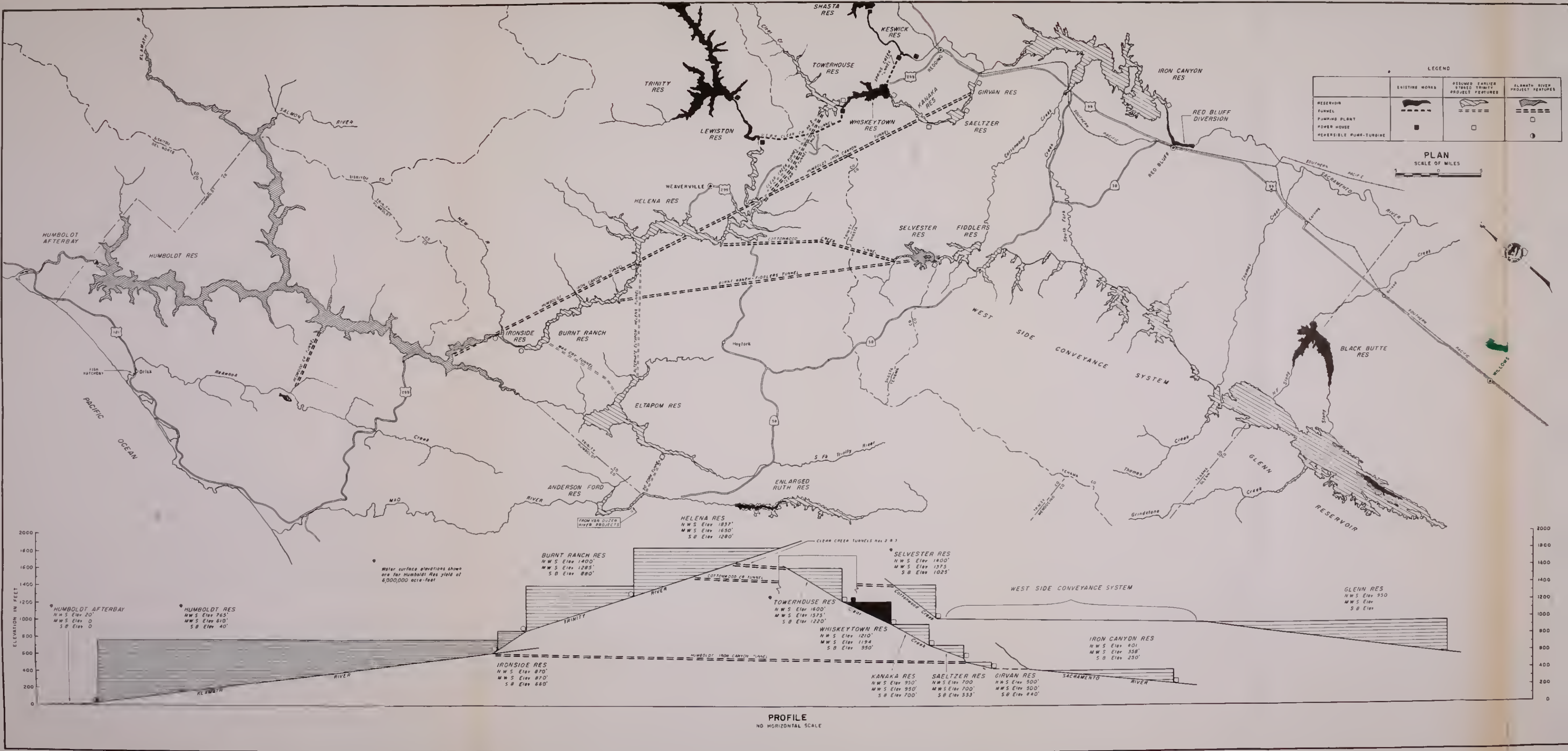


SHASTA RES
KESWICK RES
TOWERHOUSE RES
TRINITY RES
WHISKEYTOWN RES
KANAKA RES
GIRVAN RES
SAELTZER RES
IRON CANYON RES
LEWISTON RES
RED BLUFF DIVERSION
LEGEND
EXISTING WORKS
RESERVOIR
TUNNEL
PUMPING PLANT
POWER HOUSE
REVERSIBLE PUMP-TURBINE
PLAN
SCALE OF MILES
WEAVERVILLE
HELENA RES
SALMON RIVER
HUMBOLDT AFTERBAY
HUMBOLDT RES
SELVESTER RES
FIDDLERS RES
IRONSIDE RES
BURNT RANCH RES
WEST SIDE CONVEYANCE SYSTEM
BLACK BUTTE RES
PACIFIC OCEAN
ELTAPOM RES
GLENN RESERVOIR
ANDERSON FORD RES
ENLARGED RUTH RES
MAD RIVER
FROM VAN DUZEN RIVER PROJECTS
HELENA RES
N W S Elev 1837'
M W S Elev 1650'
S B Elev 1280'
CLEAR CREEK TUNNELS Nos 2 & 3
BURNT RANCH RES
N W S Elev 1400'
M W S Elev 1285'
S B Elev 880'
SELVESTER RES
N W S Elev 1400'
M W S Elev 1375
S B Elev 1025'
Water surface elevations shown are for Humboldt Res yield of 6,000,000 acre-feet
COTTONWOOD CR TUNNEL
WEST SIDE CONVEYANCE SYSTEM
GLENN RES
N W S Elev 950
HUMBOLDT AFTERBAY
N W S Elev 20'
M W S Elev 0
S B Elev 0
HUMBOLDT RES
N W S Elev 765'
M W S Elev 610'
S B Elev 40'
TOWERHOUSE RES
N W S Elev 1600'
M W S Elev 1575'
S B Elev 1220'
WHISKEYTOWN RES
N W S Elev 1210'
M W S Elev 1194
S B Elev 950'
IRON CANYON RES
N W S Elev 401
M W S Elev 358'
S B Elev 230'
HUMBOLDT IRON CANYON TUNNEL
IRONSIDE RES
N W S Elev 870'
M W S Elev 870'
S B Elev 660'
KANAKA RES
N W S Elev 950'
M W S Elev 950'
S B Elev 700'
SAELTZER RES
N W S Elev 700
M W S Elev 700'
S B Elev 533'
GIRVAN RES
N W S Elev 500'
M W S Elev 500'
S B Elev 440'
KLAMATH RIVER
TRINITY RIVER
SACRAMENTO RIVER
ELEVATION IN FEET
PROFILE
NO HORIZONTAL SCALE

CHART A
RESERVOIR AREA-CAPACITY DATA
HUMBOLDT RESERVOIR

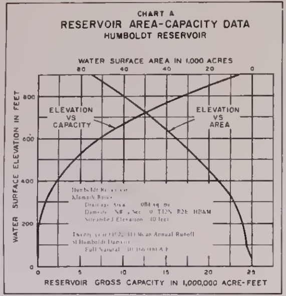


CHART B
RESERVOIR YIELD-CAPACITY DATA
HUMBOLDT RESERVOIR
YIELD ON A UNIFORM SCHEDULE

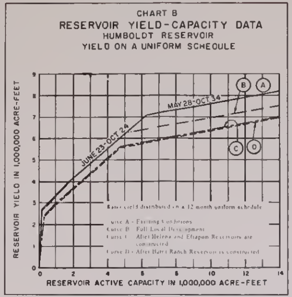


CHART C
RESERVOIR YIELD-CAPACITY DATA
HUMBOLDT RESERVOIR
YIELD ON A POWER SCHEDULE

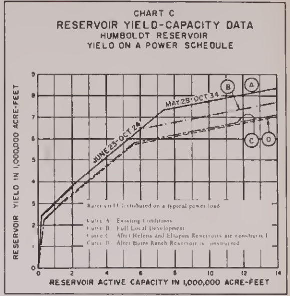


CHART D
RESERVOIR COST-CAPACITY DATA
HUMBOLDT RESERVOIR

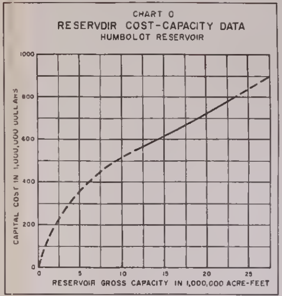


CHART E
UNIT COST OF ACTIVE STORAGE
HUMBOLDT RESERVOIR

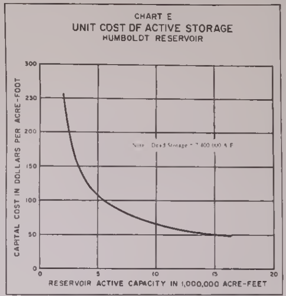


CHART F
UNIT COST-YIELD DATA
HUMBOLDT RESERVOIR

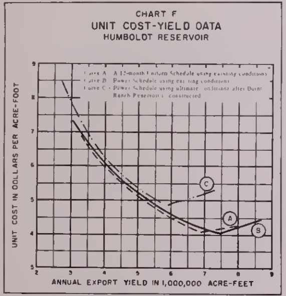


CHART G
CAPITAL COST-INSTALLED CAPACITY DATA
HUMBOLDT POWER FACILITIES

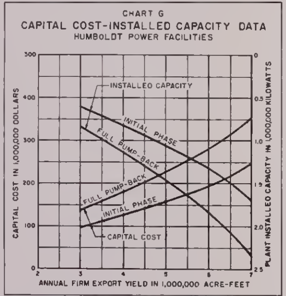


CHART H
NET REVENUE-NET UNIT REVENUE DATA
HUMBOLDT POWER FACILITIES
WITH OR WITHOUT REVERSIBLE UNITS

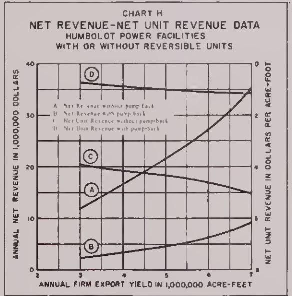


CHART I
CAPITAL COST AND DIAMETER VS. YIELD
EXPORT TUNNELS

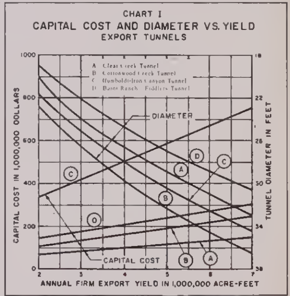


CHART J
CAPITAL COST AND INSTALLED CAPACITY VS. YIELD
TRINITY RIVER PUMPING PLANTS

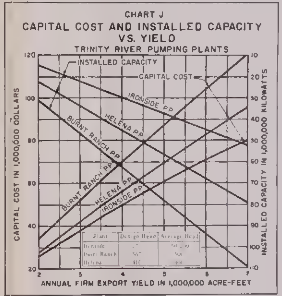


CHART K
ANNUAL COST VS. YIELD DATA
TRINITY RIVER PUMPING PLANTS

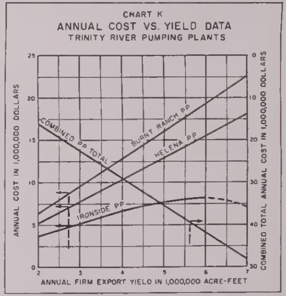


CHART L
CAPITAL COST AND NET ANNUAL REVENUE
CLEAR CREEK POWER FACILITIES

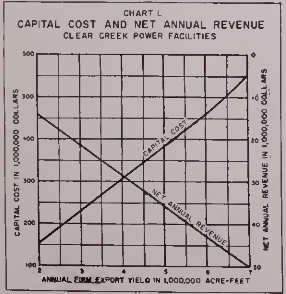


CHART M
CAPITAL COST AND NET ANNUAL REVENUE
COTTONWOOD CREEK POWER FACILITIES

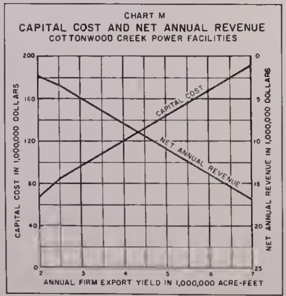


CHART N
CAPITAL AND UNIT COST OF WATER DELIVERED TO IRON CANYON RESERVOIR VIA CLEAR CREEK DURING THE DEMAND BUILD-UP
(WITH AND WITHOUT HUMBOLDT PUMP-TURBINE PLANT)

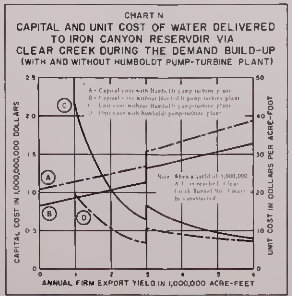


CHART O
CAPITAL COST OF WATER DELIVERED TO IRON CANYON OR FIDDLERS RESERVOIR VIA ALL FOUR CONVEYANCE ROUTES
(WITHOUT HUMBOLDT PUMP-TURBINE PLANT)

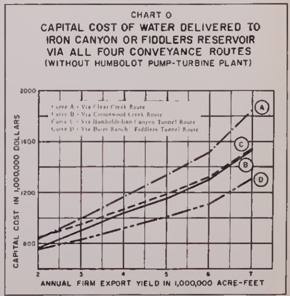
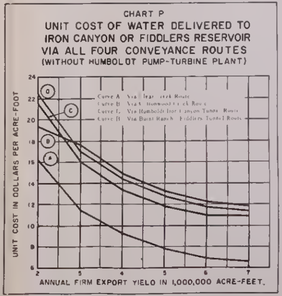


CHART P
UNIT COST OF WATER DELIVERED TO IRON CANYON OR FIDDLERS RESERVOIR VIA ALL FOUR CONVEYANCE ROUTES
(WITHOUT HUMBOLDT PUMP-TURBINE PLANT)



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH
NORTH COASTAL AREA INVESTIGATION
KLAMATH RIVER DIVISION
1964

HUMBOLDT RESERVOIR PROJECT

RECONNAISSANCE SUMMARY OF COSTS FOR DEVELOPMENT AND TRANSPORTATION OF NEW FIRM WATER YIELD TO IRON CANYON RESERVOIR OR THE WEST SIDE CONVEYANCE SYSTEM

effe
Girv
Girv

Ranc
West
voir
Syst
woul
crea
with